AD-A112 601 NAVAL RESEARCH LAB . WASHINGTON DC SHOCK AND VIBRATION--ETC F/G 20/11
THE SHOCK AND VIBRATION DIGEST, VOLUME 4, NUMBER 6,(U)
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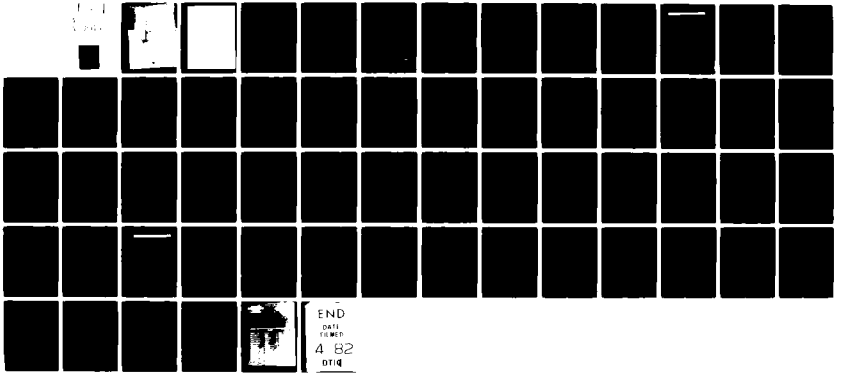

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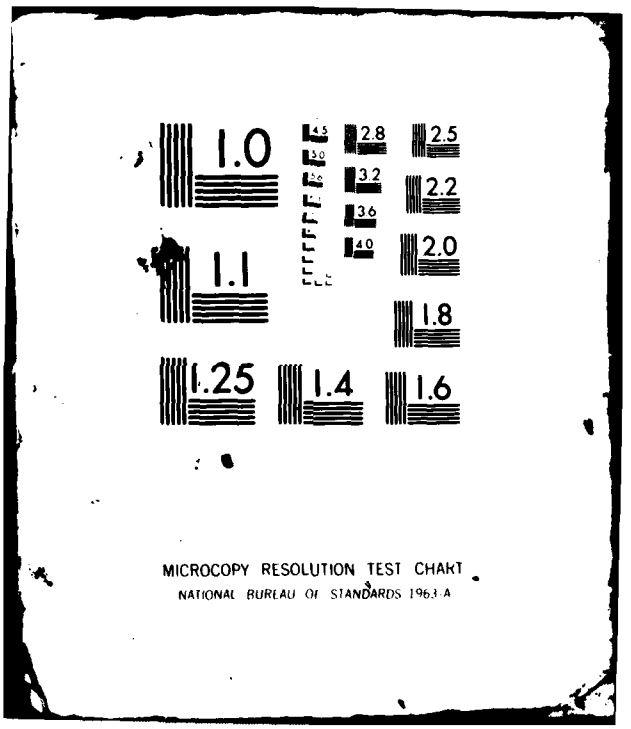
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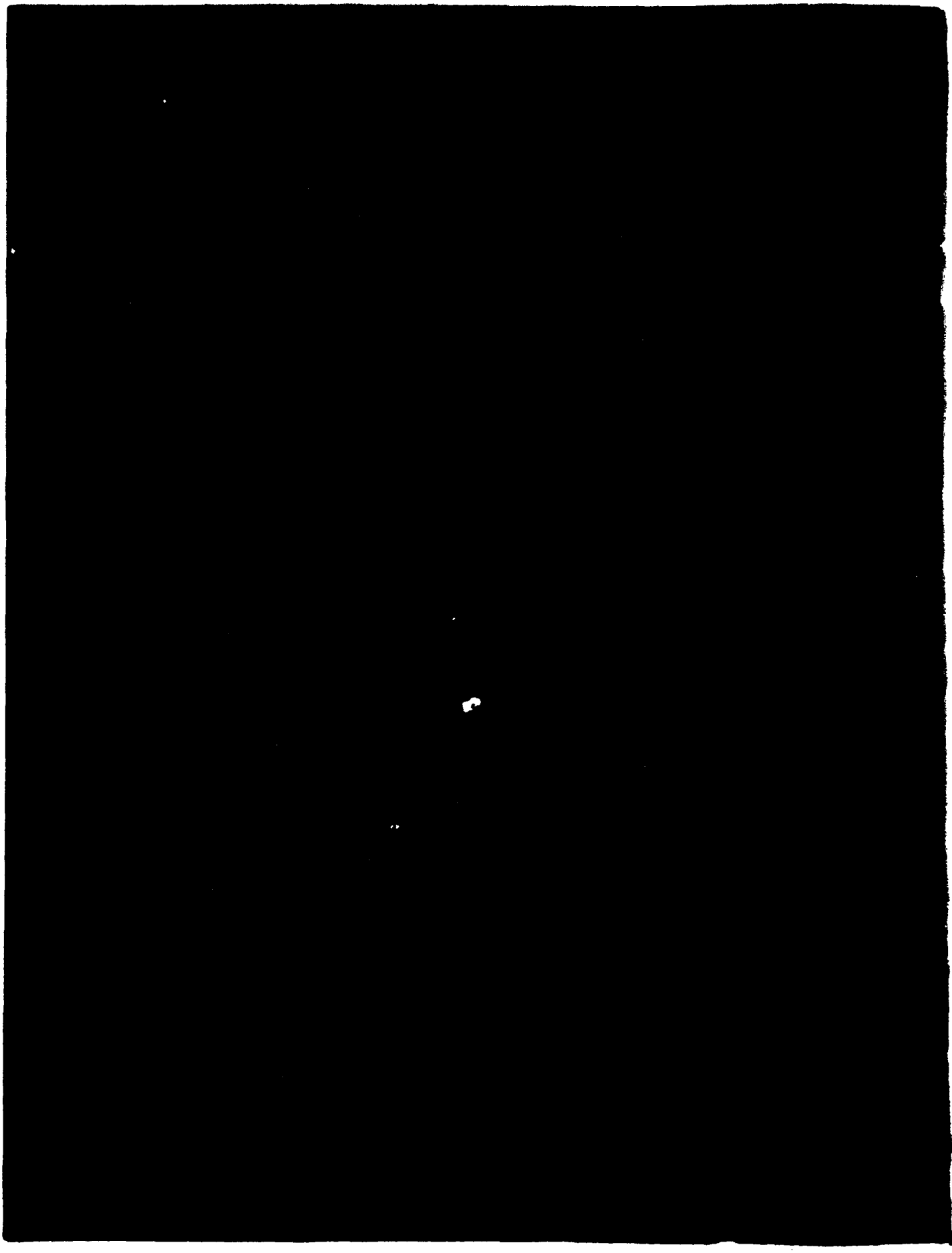

EDITORS RATTLE SPACE

IS SHOCK AND VIBRATION ENGINEERING MATURE?

Compared to his cousin the noise control engineer, the shock and vibration engineer has suffered more often from a delusion that his domain is an exact science. This came about in part because of the amount of help he has had, and the attitudes of the helpers. When he was pioneering 15 or more years ago, he was seldom, even by the standards of a systems engineering team, left to make his own decisions and take his own risks. Everyone took part, especially in the determination of acceptable test conditions. Designers who were afraid their equipment might not pass tests, and managers, who were concerned with cost and schedule as well as reliability, all took part, for understandable enough reasons. The prevailing attitude was that equipment should be tested to exactly what it would experience in use — not one g more or even a tenth of a g more. In spite of this, the bulk of the people involved in the negotiations did not understand the shock and vibration environments, and reliable quantitative data were scarce. The shock and vibration engineer made his compromises rather defensively. Through it all, he had forced on him the myth of an exact determination of the shock and vibration environment, and an exact simulation in test. And officially, there were no nontechnical constraints provided he could somehow reduce these myths to practice.

The noise control engineer, in contrast, knew from the beginning, and was permitted to state, that even with the greatest care in noise measurements, he was subject to obvious uncertainties. What constituted annoyance was difficult to define. What constituted a hazard to hearing was difficult to establish quantitatively. With the accelerating trend of control of noise through legislation, the noise control engineer has come to accept also a legal as well as technical basis for his activities, and to recognize that sometimes the legal aspects may be even more important.

In recent years, the shock and vibration engineer has learned more about the environments with which he is concerned, the capabilities and limitations of data reduction, the capabilities and limitations of simulation, and the numerous other factors influencing his work. He can now hold his own with his helpers. But he still suffers from the confusions forced upon him in his pioneering days.

Progress thus far has been an uphill battle. Technical societies have usually been oriented more toward fundamentals than application. When they were unfamiliar with application, they often recognized no criteria of merit but those related to fundamentals -- the more fundamental a paper appears to be the more application it must obviously have. Conversely, if it reveals no new fundamentals, it must obviously have no application. The shock and vibration engineer frequently found his papers rated unacceptable.

For this and other practical reasons, he depended almost entirely on the Shock and Vibration Symposium and, more recently, the Shock and Vibration Information Center, for his professional development. He had an important engineering job to get done. He had need to communicate with his peers. Often, he needed a forum where various points of view could be presented, and the real issues would gradually emerge.

The shock and vibration specification has never been a purely technical document. It always was and remains largely a management tool for obtaining reliability to schedule and at acceptable cost. Its feasible properties are in many respects counterparts of those of the Walsh-Healey Act and other noise control legislation. The government, as the ultimate customer for most of the hardware developed using this tool, has shown commendable wisdom in supporting the Symposium and the Center. The shock and vibration engineer has needed and still needs a home such as this in which to communicate and to develop.

Can he now accept the nontechnical or at least nonscientific aspects of the shock and vibration specification? He has less need for the myth of exact science as a crutch than in the early pioneering days. He has more available theory, more experience, and more perspective. But only through clear understanding and acceptance of objectives does one attain true responsibility and maturity.

C. T. M.

THE 83RD MEETING OF THE ACOUSTICAL SOCIETY OF AMERICA

18-21 April 1972
Buffalo, N.Y.

The attendance at the meeting, nearly 900, was large compared with that at last year's meetings. The sessions ranged over almost all aspects of acoustics and included a plenary session, which was attended by a majority of the registrants. It was noted that the interest is shifting to practical problems, for instance, the sessions on noise were usually crowded, while those on other topics drew only a small number of persons.

The title of the plenary sessions was "Three Perspectives of Acoustics." The individual talks were: "Acoustics as a Physical Science", by Robert T. Beyer, "Acoustics as a Human Science", by S. S. Stevens and Applied Acoustics and Its Role in Modern Society", by Daniel R. Flynn. All three emphasized practical aspects of acoustics, with noise and its control as the main topic. The role of the Society in environmental problems and protection was discussed.

The Technical Committee on Shock and Vibration was responsible for four sessions. The first of these, Vibration of Solids, was, judging by the abstracts, largely of a theoretical nature and dealt with such subjects as stress-wave propagation in elastic rods, vibration of shells, beams and plates, etc. The second session was devoted to macrosonics, the application of high-intensity sonic power to industrial processes. This started with a paper by Dr. Balamuth on the sonic motor, in which he showed that it is possible to obtain a wide range of output velocities, while maintaining a safe stress in the transducer material without the aid of a velocity transformer. Sonic metal working processes were discussed by Shoh, Byron Jones and Janet Devine and McKaig. Smith and Stewart introduced Federal regulations aimed at potential hazards of ultrasonic radiations, while Boucher and Last described experiments on the use of ultrasonic energy in sterilization. The third session, Analytical Techniques, started with a paper by Shajenko on the use of holographic interferometry, in which he showed several beautiful photographs of interference fringes of vibrating plates and loudspeaker diaphragms. Reddy and Lowery discussed model studies in a shock tube of the transient response of a double resonator. This was aimed at finding the response of buildings to sonic boom. Another paper in this session by Pilkey and Wang on "Optimal Performance of Physical Systems Subject to Impact" introduced the idea of describing as a function of time such systems as shock absorbers, vibration isolators, mountings, etc., while keeping the peak response of the shock excited systems within prescribed limits. The actual design of the coupling systems follows the determination of the time function. Computer programs are available to carry out the computations for systems with many degrees of freedom. The fourth session, Dynamic Characteristics of Anthropomorphic Dummies and Auto Crash Studies, must have seemed out of place to classical acousticians, being entirely devoted to the effects of impact on human beings and the design of dummies used in studies to minimize those effects. Several films showing controlled crashes were shown. It was noted that with proper protection the human body may be able to withstand a deceleration of the order of 60 g.

The Technical Committee on Noise arranged several sessions. The first and third were devoted to the measurement of machine noise in reverberant rooms. While broadband noise does not pose a problem, the presence of discrete frequencies in the spectrum may lead to large errors. Stationary and moving reflectors are used to minimize these errors. Many laboratories use rotating vanes for this purpose. This session was followed by a long discussion period, indicating the concern of noise control engineers with this problem.

The second session had as its topic noise measurement of machines as installed. Lang discussed ANSI and ISO standards on this topic and test codes by engineering societies and trade associations. Other papers dealt with the semi-reverberant character of most spaces and with

characterization of noise sources. In five general sessions on noise, propagation of sound in ducts, noise control for vehicles and stationary noise sources, jet and propeller/noise, community noise and noise measurement and the effects of noise on man were the main topics. In addition to these, the after-dinner speaker at the banquet, Dr. Karl Willenbrock used as his subject "Noise Systems -- Physical and Managerial." A large part of his talk was devoted to the role of the federal government in noise pollution and its control.

At the meeting of the Technical Committee on Shock and Vibration, topics for sessions at future ASA meetings were arranged. These include: "Structural Response and Failure Mechanisms under Stationary and Nonstationary Random Excitation" and "Recent Trends in Optical Imaging for Vibration Measurements" at the November 1972 meeting in Miami Beach; two joint sessions with the Technical Committee on Noise on "Control and Measurement of Shock Excited Vibration and Noise"; "Calibration of Velocity Measuring Systems", "Machine Tool Vibrations" at the Boston meeting in April 1973; and two sessions on "Measurement of Damping of Materials and Composites and in Structures" as well as another session on "Applied Macrosonics" jointly sponsored with the Technical Committee on Engineering Acoustics at the Los Angeles meeting in October 1973.

A. S.

SYMPOSIUM ON NONLINEAR DYNAMICS

27-28 March, 1972
University of Technology
Loughborough, U.K.

This meeting, believed to be the first of its kind held in the United Kingdom on this specific topic, was sponsored by the Aeronautical Research Council, British Acoustical Society and the Royal Aeronautical Society. Sixteen papers were presented in five sessions which allowed ample time for discussion. The papers could perhaps be classified in groups as follows:

(1) Four dealt with analytical techniques for solving nonlinear differential equations and it was shown that nonlinear systems having n degree-of-freedom may be tackled for certain classes of problems. The method considers systems having continuously changing damping and frequency.

(2) One dealt with the application of Lyapunov functionals to nonlinear dynamics and the stability of such systems.

(3) Three papers were given on: subharmonic oscillations of specific structures have skew-symmetric nonlinear stiffnesses; on the free vibrations of arches and on the free and forced vibration (with hysteretic damping) of circular shells. The methods of analyses in each case were different and the respective advantages of each can therefore be judged.

(4) Two papers were concerned with the deterministic analysis of the strongly nonlinear behavior of aircraft traveling over rough runway surfaces. The basic physical problem was described and the governing equations presented. An approach to optimum design of the undercarriage characteristics using a hybrid computer was also presented. Specific results for the Concorde SST and other aircraft were given.

(5) Two papers dealt with the application of power spectral density methods to response of aircraft to runway roughness and to atmospheric turbulence. The former utilized a somewhat simpler nonlinear model but showed that "equivalent linearization" yielded good results and that an optimum design could be so obtained. The latter considered nonlinear aerodynamic forces and moments in a three degree-of-freedom analysis of a rigid aircraft.

(6) Three papers were concerned in whole or in part with parametric or auto-parametric instabilities of beam and plate structures. Modal coupling was shown in one to be most important in producing a beating traveling wave effect in the structure.

(7) One paper dealt with frictional damping in beams and from a throretical and experimental study concluded that simple linearized analysis may be applied to the problem concerned and that an optimum friction force applies for minimum amplitude frequency response of a system with several degrees-of-freedom.

(8) The Symposium Proceedings are available from Loughborough University of Technology, U.K., at a price of £4.50 or $12 including postage.

D. J. Johns

JULY

DYNAMICS OF VEHICLES AND OCCUPANTS IN SEVERE MOTION
Place: Univ. Mich.
Dates: July 10-14
Objective: The use of the digital computer and computer graphic terminals in predicting motions and forces in vehicle and vehicle occupants under conditions of severe maneuvers and crash will be examined.
Contact: Engr. Summer Conf., Chrysler Ctr., North Campus, Univ. Mich., Ann Arbor, Mich. 48105

NOISE AND VIBRATION CONTROL
Place: Mass. Inst. Tech.
Dates: July 30-Aug. 5
Objective: This program is directed toward engineers who anticipate responsibility for the design of noise control or for the writing of noise specifications or legislation or who may be involved in the management of company-wide noise-control programs.
Contact: Director of the Summer Session, MIT, Cambridge, Mass. 02139

AUGUST

COMPUTER PROGRAMS FOR STRUCTURAL ANALYSIS
Place: Univ. S. Calif.
Dates: Aug. 7-11
Objective: The theory used in development of the computer programs will be given by lecturers currently involved in the formulation of new computer analysis in the structural mechanics field. The finite element and finite difference methods will be discussed in detail. The capability and availability of the general purpose structural analysis program NASTRAN will be discussed.
Contact: Noncredit Programs Adm. 353, Univ., Calif., Los Angeles, Calif. 90007

NOISE REDUCTION IN MECHANICAL SYSTEMS: FUNDAMENTALS AND ADVANCED CONSIDERATIONS
Place: Univ. Mich.
Dates: Aug. 7-18
Objective: Practicing engineers and engineering management will be offered an up-to-date, comprehensive, and practical working knowledge of noise reduction engineering and criteria for allowable noise.
Contact: Engr. Summer Conf., Chrysler Ctr., North Campus, Univ. Mich., Ann Arbor, Mich. 48105

MOTOR VEHICLE PERFORMANCE -- MEASUREMENT AND PREDICTION
Place: Univ. Mich.
Dates: Aug. 16-18
Objective: The advances being made to make the measurement and assessment of motor vehicle performance (braking, cornering, roadholding, ride, etc.) a highly objective activity will be emphasized.
Contact: Engr. Summer Conf., Chrysler Ctr., North Campus, Univ. Mich., Ann Arbor, Mich. 48105

VIBRATION AND SHOCK TESTING
Place: Santa Barbara, Calif.
Dates: Aug. 21-25
Objective: The course is designed for quality assurance, evaluation and test personnel who are concerned with maximum reliability of missiles, aircraft, submarines, electronics, process industries, etc., where vibration and shock are hazardous environments. The seminar will concentrate on modern laboratory practice, equipment and techniques with a minimum of theory and mathematics.
Contact: Tustin Inst. Tech., Inc., 22 E. Los Olivos St., Santa Barbara, Calif. 93105

PYROTECHNICS AND EXPLOSIVES
Place: Philadelphia, Pa.
Dates: Aug. 21-25
Objective: The course will be welcomed both by newcomers to the field as well as by experienced men who wish to brush up on latest developments. Coverage emphasizes recent effort, student problems, new techniques, and applications.
Contact: Mr. Gunther Cohn, Registrar, The Franklin Inst. Res. Labs., Philadelphia, Pa. 19103

NOISE AND VIBRATION CONTROL IN BUILDINGS
Place: Vancouver, B.C., Canada
Dates: Aug. 29-31
Objective: Emphasis will be placed on practical acoustics and architectural and engineering noise control. The printed lecture notes providing extensive tables of valuable noise and noise control data, and a documentation of the entire course will be given.
Contact: Miss G. A. Cianci or Mrs. C.S. Kelly, Bolt Beranek and Newman, Inc., 50 Moulton St., Dept. C, Cambridge, Mass. 02138

ABSTRACT CATEGORIES FOR THE SHOCK AND VIBRATION DIGEST

ANALYSIS AND DESIGN

- Analogs and Analog Computation
- Analytical Methods
- Impedance Methods
- Integral Transforms
- Nonlinear Analysis
- Numerical Analysis
- Optimization Techniques
- Perturbation Methods
- Stability Analysis
- Statistical Methods
- Variational Methods
- Finite Element Modeling
- Modeling
- Computer Programs
- Digital Simulation
- Parameter Identification
- Design Information
- Design Techniques
- Standards and Specifications
- Surveys
- Tutorial

ENVIRONMENTS

- Acoustic
- Periodic
- Random
- Seismic
- Shock
- General Weapon
- Transportation

PHENOMENOLOGY

- Composite
- Damping
- Elastic
- Fluid
- Inelastic
- Soil
- Thermoelastic
- Viscoelastic

EXPERIMENTATION

- Data Reduction
- Diagnostics
- Equipment
- Experiment Design
- Facilities
- Instrumentation
- Procedures
- Scaling and Modeling
- Simulators
- Specifications
- Techniques

COMPONENTS

- Absorbers
- Beams, Strings, Rods
- Bearings
- Blades
- Columns
- Controls
- Ducts
- Frames
- Gears
- Isolators
- Linkages
- Mechanical
- Membranes
- Panels
- Pipes
- Plates and Shells
- Rings
- Springs
- Structural

SYSTEMS

- Absorber
- Acoustic Isolation
- Active Isolation
- Aircraft
- Artillery
- Bioengineering
- Bridges
- Building
- Cabinets
- Construction
- Earth
- Electrical
- Helicopters
- Human
- Isolation
- Material Handling
- Mechanical
- Metal Working and Forming
- Off-Road Vehicles
- Optical
- Package
- Pressure Vessels
- Pumps, Turbines, Fans, Compressors
- Rail
- Reactors
- Reciprocating Machine
- Road
- Rotors
- Satellite
- Self-Excited
- Ship
- Spacecraft
- Structural
- Transmissions
- Turbomachinery
- Useful Application

DOCUMENT INFORMATION

Copies of articles abstracted are not available from the Shock and Vibration Information Center (except for those generated by SVIC). Inquiries should be directed to library resources, authors, or the original publishers. According to prefixed letters on document numbers, articles can be obtained from the following agencies:

AD, N } Defense Documentation Center, Document Library, Cameron Station, Alexandria, Va. 22314

ASME - American Society of Mechanical Engineers, 345 E. 47th St., New York, N.Y. 10017

NASA - National Aeronautics and Space Administration, Scientific and Technical Information Division, Washington, D.C. 20546

NSA - Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (or NTIS)

PB - National Technical Information Service, Dept. *Commerce*, *Springfield*, Va. 22151

SAE - Society of Automotive Engineers, 2 Pennsylvania Plaza, New York, N.Y. 10001

Patent descriptions should be requested from the U.S. Patent Office, Washington, D.C. 20231. Doctoral theses are available from University Microfilms (UM), 313 No. Fir St., Ann Arbor, Mich.

Addresses following the authors' names in the abstracts refer only to the first author listed.

ANALYSIS AND DESIGN

ANALYTICAL METHODS

72-908

EXACT SOLUTIONS OF THE EQUATION FOR THE FREE TORSIONAL OSCILLATIONS OF AN INHOMOGENEOUS SPHERE
Bhattacharya, S.N. (Seismol. Observatory, India Meteorological Dept., Lodi Road, New Delhi 3, India)
Bull. Seismol. Soc. Am. 62(1), 31-38 (Feb. 1972) 13 refs

Key Words: equations of motion, inhomogeneous sphere, torsional response

The equation of motion of free torsional oscillations of an inhomogeneous sphere where the modulus of rigidity and density are functions of distance from the center of the sphere is considered. A systematic method is developed to obtain the inhomogeneity for which the equation can be solved in terms of hypergeometric, Whittaker and Bessel functions. A few simple inhomogeneities yielding exact solutions in terms of these functions are presented.

72-909

NORMAL MODE SOLUTIONS OF LINEAR DYNAMIC FIELD THEORIES USING GREEN'S EXTENDED IDENTITY
Cinelli, G. and Pilkey, W.D. (Argonne Natl. Lab., Argonne, Ill.)
Intl. J. Engr. Sci. 9(11), 1123-1141 (Nov. 1971) 5 refs

Key Words: eigenvalue problems, Green's extended identity, normal modes

Normal mode solutions of certain classes of linear, spatially time-invariant, self-adjoint and nonself-adjoint differential operators, with inhomogeneous boundary conditions in a finite region of arbitrary shape, are obtained by the use of Green's extended identity in conjunction with the eigenvalue problems associated with the differential operators. Thus, continuum field theories belonging to these classes of operators, which encompass arbitrary (1) material and geometrical parameters, (2) spatial and time-dependent boundary conditions, and (3) initial conditions can be solved by this technique. This is illustrated by the determination of the transient response of an axisymmetric, finite, thick transversely isotropic elastic hollow cylinder under inhomogeneous boundary conditions of all types (both pure and mixed). It is also shown that the displacement (separation-of-variables, integral transforms) and acceleration (Mindlin-Goodman, Williams) methods currently used for solutions of dynamic problems can both be derived from Green's extended identity.

72-910

INTEGRATION OPERATORS FOR TRANSIENT STRUCTURAL RESPONSE
Dunham, R.S.; Nickell, R.E.; and Stickler, D.C. (Dept. C.E., Univ. Texas, Austin, Tex.)
Computers and Structures 2(1 and 2), 1-15 (Feb. 1972) 18 refs

Key Words: dynamic response, Newmark method, structural response

Criteria for choosing an optimum approximate integration operator in problems of forced dynamic structural response are demonstrated. It is concluded that a modally uncoupled precise integration operator has advantages for many, including nonlinear, problems. Of the current popular operators for direct integration of the equations of motion, the Newmark method with appropriately chosen parameters is found to be superior.

72-911

SUPERIMPOSING OF DETERMINIST AND RANDOM INFLUENCES AT NONLINEAR OSCILLATION SYSTEMS
Heimann, B. (Deutsche Akademie der Wissenschaften zu Berlin, Zentralinstitut für Mathematik und Mechanik)
Maschinenbautechnik 21(2), 61-65 (Feb. 1972) 8 refs

Key Words: nonlinear systems, oscillation

Approximate solutions by equivalent statistical linearization are stated for a nonlinear oscillation system with one degree of freedom and

exposed simultaneous periodic and accidental excitations. From the random function, it is learned that the system has normal distribution, is centralized, and has high-frequency periodic influences. Numerical interpretations are carried out for some concrete parameter combinations. (In German)

72-912

PERIODIC VIBRATIONS IN THE VARIABLE STRUCTURE NONLINEAR SYSTEM
Kudrewicz, J. (Inst. Automatic Control, Polish Acad. Sci. Warsaw, Krajowej Rady Narowej 55)
Bull. de L'Académie Polonaise des Sciences, Série des Sciences Techniques 19(9), 51-55 (1971) 5 refs

Key Words: nonlinear systems, periodic response

The periodic vibrations in a variable structure nonlinear system are studied. An approximate solution is obtained. The theorem on the existence of periodic solution in a neighborhood of the approximate solution is given. The proof of this theorem is based upon Krasnosielski's theorem on the weakly connected equations and upon the theorem on the continuity of Hammerstein's integral operator.

72-913

REAL EIGENVALUES OF SYMMETRIC MATRIXES
Sheldon, C.
Naval Postgraduate Sch., Monterey, Calif.
MS Thesis (Sept. 1971) 37 pp

Key Words: cantilever beams, eigenvalue problems, finite difference technique

The thesis is concerned with proving that the eigenvalues of a specific unsymmetric matrix are real and positive, without actually computing them. The method of finite differences is applied to the vibration analysis of a cantilever beam and leads to an unsymmetric stiffness matrix in the eigenvalue problem formulation. The technique employed in the proof is based on perturbation theory given by Wilkinson for real symmetric matrixes. Application of the theory is made to the cantilever beam eigenvalue problem. The results verify that the eigenvalues of this and other unsymmetric matrixes can be proved to be real and positive without their actual values being calculated.
AD-736116

72-914

A REAL FREQUENCY, COMPLEX WAVE-NUMBER ANALYSIS OF LEAKING MODES
Watson, T.H. (Gulf Research and Development Co., Pittsburgh, Pa.)
Bull. Seismol. Soc. Am. 62(1), 369-384 (Feb. 1972) 15 refs

Key Words: elastic waves, leaking modes, modal analysis, wave propagation

Leaking-mode dispersion and attenuation is computed for two single-layer models. Roots of the dispersion relation are obtained in the complex wavenumber plane, using real frequency as the independent variable. At low frequencies the root loci on the (+,+) sheet determine the fundamental propagating mode plus a series of attenuated standing-wave modes in the vicinity of the source. As frequency increases, the complex roots on all four sheets migrate through the wavenumber plane, producing (successively) organ-pipe modes, PL modes, and normal modes. For higher frequencies, the modes exhibit a tendency to couple with a pure P- (and S-) type motion in the wave guide. These effects are related to similar phenomena which occur for the case of the free elastic plate.

INTEGRAL TRANSFORMS

72-915

DYNAMIC ANALYSIS BY EXTRA FAST FOURIER TRANSFORM
Meek, J.W. and Velestos, A.S. (Dept. Civ. Engr., Rice Univ., Houston, Tex.)
ASCE, J. Eng. Mech. Div. 98(EM2), 367-384 (Apr. 1972) 7 refs

Key Words: discrete Fourier transform, fast Fourier transform, periodic excitation, transient response

A method based on the Discrete Fourier Transform (DFT) is presented for evaluating the dynamic response of any discrete, time invariant, linear system to an excitation, the spatial distribution of which is constant and the timewise variation of which may be represented by a string of equally spaced impulses of arbitrary magnitudes. In addition to being faster and more efficient than available DFT approaches, the method may be adopted to the processing of arbitrarily long excitations as a series of short, independent segments. The length of the individual segments may be chosen to optimize computational efficiency. The method consists of taking advantage of the periodicity implicit in

the DFT approach and evaluating first the response of the system to a periodic extension of the excitation. A simple corrective solution is then superposed which converts the periodic response to the desired transient response. The method is illustrated by two numerical examples.

NONLINEAR ANALYSIS

(Also see Nos. 924, 928, 978, 988)

72-916

A PERTURBATION ANALYSIS OF NONLINEAR FREE FLEXURAL VIBRATIONS OF A CIRCULAR CYLINDRICAL SHELL.
Atluri, S. (Dept. of Aeronaut. and Astronaut., Univ. Washington, Seattle, Wash.)
Intl. J. Solids Struct. 8(4), 549-569 (Apr. 1972) 23 refs

Key Words: cylindrical shells, Donnell theory, free vibrations

Nonlinear free vibrations of a circular cylindrical shell are examined using Donnell's equations. A modal expansion is used for the normal displacement that satisfies the boundary conditions for the normal displacement exactly, but the boundary conditions for the in-plane displacements are satisfied approximately by an averaging technique. Galerkin technique is used to reduce the problem to a system of coupled nonlinear ordinary differential equations for the modal amplitudes. These equations are solved for arbitrary initial conditions by using the multiple-time-scaling technique. Explicit values of the coefficients that appear in the foremention Galerkin system of equations are given, in terms of nondimensional parameters characterizing the shell geometry and material properties, for a three mode case, for which results for specific initial conditions are presented. A comparison of the results with those obtained in previous studies of the problem is presented and the discrepancies are discussed.

PERTUBATION METHODS

72-917

ON THE INVERSE PROBLEM OF NATURAL VIBRATIONS OF ELASTIC SHELLS
Ainola, L. Ia.
Appl. Math. Mech. 35(2), 317-323 (1971) (Engl. Transl. of Prikladnaya Matematika i Mekhanika 35(2), 358-364 (1971))
12 refs

Key Words: inverse problems, natural vibration, shells

The problem of determining small changes in the geometric parameters of elastic bodies is considered. It is assumed that the frequency spectrum of their natural vibrations should have given small changes. As an illustration, the problem of determining the variable stiffness of an elastic beam as well as the problem of determining the meridian shape of shells of revolution by means of given frequencies of natural vibrations are considered. Only a few papers are devoted to inverse problems of elastic body vibrations. However, the problem of determining the density of an inhomogeneous string by means of its frequency spectra has been investigated with mathematical rigor.

72-918

NONLINEAR ACOUSTIC RESPONSE ANALYSIS OF PLATES USING THE FINITE ELEMENT METHOD
Hwang, C. and Pi, W.S. (Northrop Corp., Aircraft Div., Hawthorne, Calif.)
AIAA J. 10(3), 276-281 (Mar. 1972)
19 refs

Key Words: acoustic excitation, finite element technique, nonlinear response, perturbation technique, plates

A perturbation technique to perform the nonlinear response analysis of plate structures under random acoustic excitation is described. In the analysis, use is made of a conforming plate element together with a nonlinear plate stiffness element which is dependent on the modal response of the structure. Applying these elements and the associated consistent mass matrixes, the equivalent linear eigenmatrix of the complete plate is organized. The eigensolution and the following modal spectral computation completes the iteration cycle. The iteration process is repeated until apparent convergent data are acquired. A flow diagram and a numerical example are included which illustrate the application of the method to practical problems.

STABILITY ANALYSIS
(Also see Nos. 981, 1031)

72-919
FOLLOWER FORCE INSTABILITY OF A POD-MOUNTED JET ENGINE
Done, G.T.S. (Univ. Edinburgh, Dept. Mech. Engr., England)
Aeronaut. J. 76(734), 103-107 (Feb. 1972)
6 refs

Key Words: aircraft engines, dynamic response

The dynamics of a simplified model of a pod-mounted jet engine are analyzed. The results of experimental tests in the laboratory and computer calculations on a practical example are presented.

72-920
ON THE STABILITY OF HAMILTONIAN SYSTEMS IN THE PRESENCE OF RESONANCES
Khazin, L.G.
Appl. Math. Mech. 35(3), 384-391 (1971)
(Engl. Transl. PMM 35(3), 423-431 (1971))
4 refs

Key Words: Hamiltonian system, stability

Necessary and sufficient conditions are obtained for the stability of the equilibrium of Hamiltonian systems in the presence of resonances.

72-921
HYDROFOIL FLUTTER ANALYSIS, USING A MODIFIED STRIP THEORY
Liu, Y. and Besch, P.K. (Naval Ship Res. and Dev. Ctr., Washington, D.C., NSRDC-3624, Jul. 1971)
56 pp

Key Words: flutter, hydrofoils

A flutter theory based on modified Yates hydrodynamic loading used to predict the flutter characteristics of five hydrofoil flutter models is described. Theoretical flutter speeds are noted when flutter is predicted to occur in a predominantly bending mode and when flutter is predicted to occur in a predominantly torsional mode. The theory may be useful for hydrofoils which are susceptible to flutter in a torsional mode.
AD-728406

STATISTICAL METHODS

72-922
FIRST PASSAGE OF NONSTATIONARY RANDOM PROCESSES
Corotis, R.B.; Vanmarcke, E.H.; and Cornell, A.C. (Civ. Engr., Northwestern Univ., Evanston, Ill.)
ASCE, J. Engr. Mech. Div. 98(EM2), 401-414 (Apr. 1972) 16 refs

Key Words: earthquake damage, power spectra, spectrum analysis, wind-induced excitation

A two-state Markov process for barrier passage statistics provides a more realistic model than the traditional Poisson process, especially for the response of a lightly damped oscillator to broadband excitation. For high barrier levels the two give similar results. With the Markov model, first passage probability depends on the first three area moments of the process power spectral density. The concept of a time-dependent power spectrum conveniently describes the frequency decomposition of the response of an oscillator suddenly exposed to broadband stationary excitation. Analytical expressions for time-dependent spectral moments lead to an evolutionary power spectral density shape parameter and improved first passage results, especially for lightly damped oscillators and short durations.

72-923
PROPERTIES OF SPECTRAL MOMENTS WITH APPLICATION TO RANDOM VIBRATION
Vanmarcke, E.H. (Civ. Engr., MIT., Cambridge, Mass.)
ASCE J. Engr. Mech. Div. 98(EM2), 425-446 (Apr. 1972) 17 refs

Key Words: random excitation, spectrum analysis

It is shown that many important reliability measures related to stationary random motion require the knowledge of two spectral parameters which depend on the first few moments of the reduced spectral density function. The first is a characteristic frequency, the second a unitless measure of the variability in the frequency content, i.e., of the bandwidth or the dispersion of the spectral density about its central frequency. For general stationary random processes, the spectral parameters are simply related to the mean square values of the process, its envelope, and their respective time derivatives. For Gaussian processes, other statistical properties, e.g., average barrier crossing rates, clump sizes, and maximum response characteristics,

are importantly related to these parameters. A derivation is given for the spectral moments of the stationary response of damped linear multidegree-of-freedom systems for which classical modal analysis is possible.

VARIATIONAL METHODS
(Also see No. 987)

FINITE ELEMENT MODELING
(Also see No. 979)

72-924
NONLINEAR DYNAMICS OF SOLIDS BY THE FINITE ELEMENT METHOD
Hartzman, M. and Hutchinson, J.R. (Lawrence Radiation Lab., Univ. Calif., Livermore, Calif.)
Computers and Structures 2 (1 and 2), 47-77 (Feb. 1972)
17 refs

Key Words: dynamic response, finite element technique

A method for analyzing the nonlinear dynamic response of deformable solids, subjected to time and space dependent thermal and mechanical loads, is developed. The nonlinearities considered in this analysis are due to the nonlinear character of the strain displacement relations and the equations of motion and to the nonlinear constitutive relations which describe the physical behavior of the material. In this investigation, elastic-plastic relations of the incremental (Prandtl-Reuss) type were chosen for material description. A displacement type finite element method is applied to reduce the governing partial differential equations to a set of simultaneous nonlinear ordinary differential equations of motion of a lumped mass system connected by three-dimensional elements. These equations are solved by applying a step-by-step numerical technique in conjunction with the constitutive relations. The analysis is specifically applied to plane strain problems. Two plane wave propagation problems and two large deformation problems of shells and beams under blast loading are investigated. Comparison of analytical or experimental results with numerical calculations indicates good agreement.

72-925
VARIATIONAL ANALYSIS OF THE FLEXING HEAD OF THE BQS-6 TRANSDUCER
Hunt, J.T.; Barach, D.; and Johnson, C. (Naval Underseas R&D Ctr., San Diego, Calif.)
NUC-TP-239 (Nov. 1971) 33 pp

Key Words: finite element technique, holographic techniques, mathematical models, transducers

A finite-element mathematical model developed for the equations of motion that are related to the BQS-6 transducer's flexing head is presented. Results show that holographic interferometry is an extremely sensitive and accurate experimental technique for measuring the small displacements of vibrating systems and that the finite element method is an excellent tool for theoretically predicting this behavior. The finite element analysis predicted all measured resonant frequencies within 5 percent. Predicted mode shapes could not be distinguished from those measured by holographic interferometry.
AD-735459

72-926
FINITE ELEMENT FOR SHOCK ANALYSIS
Neubert, V.H. (Penn. State Univ., Dept. Engr. Mech., University Park, Pa.)
Progress Rept. No. 2 (Sept. 1971) 100 pp

Key Words: beams, Bernoulli-Euler theory, finite element techniques, shock response, Timoshenko theory, vibration response

Finite elements are summarized as developed for bars, shafts in torsion, Bernoulli-Euler beams and Timoshenko beams. The elements were derived as black boxes which would have correct modal forces or impedances correct at the terminal points. The elements as presented may be used directly in most existing computer programs for shock and vibration analysis of structures.
AD-735923

72-927
A CONSISTENT FINITE ELEMENT METHOD FOR RANDOM RESPONSE PROBLEMS
Olson, M.D. (Dept. Civil Engr., Univ. British Columbia, Vancouver, Canada)
Computers and Structures 2 (1 and 2), 163-180 (Feb. 1972) 11 refs

Key Words: beams, finite element technique, modal analysis, random response

A consistent finite element method for analyzing the random response of complex structures is developed. The method is based on the standard modal approach but using the mode shapes obtained from a finite element representation of the structure. A polynomial representation over each finite element of the excitation cross spectral density function is then introduced. This allows the spatial integrations involved in evaluating the modal force cross spectral matrix to be carried out in closed form and this matrix to be calculated by an automatic computer process. The method is illustrated by calculating the random response of a five-bay continuous beam, a problem presenting some difficulty in the normal methods.

72-928

A COMPUTER BASED PROCEDURE FOR PREDICTING THE TRANSIENT RESPONSE AND FAILURE OF A TWO-DIMENSIONAL CONTINUUM WITH NONLINEAR MATERIAL *CHARACTERISTICS*
Wallace, D.B.
Univ. Wisc., PhD Thesis (1971) 424 pp

Key Words: finite element technique, structural members, transient response

This study deals with the development of a computer based procedure for analysis of the response of a two-dimensional continuum to transient disturbance. The stiffness characteristics of the structural idealization are generated by a finite element procedure. Elastic, inelastic, plastic and other nonlinear material properties and failure theories can be incorporated in the analysis. The examples considered to illustrate the procedure include longitudinal impact of bars with coulomb friction on the boundary, cantilever beams with different end conditions subjected to Hertzian impact, central impact of cylinders, scabbing of steel plates subjected to explosive loading, and transient response of gear teeth to a fast moving normal load and their fracture under impact. The computer solution is checked for some of these cases by experimental and different theoretical procedures. The developed technique gives a powerful tool for the analysis of transient stresses, deformations, yield and fracture patterns in a two-dimensional continuum with arbitrary geometry and nonlinear properties.
UM 72-2662

MODELING

(Also see Nos. 924, 930, 959)

72-929

SIMPLIFIED DYNAMICS OF MULTILAYERED ORTHOTROPIC VISCOELASTIC PLATES
Biot, M.A. (Avenue Paul Hymans 117, 1200 Brussels, Belguim)
Intl. J. Solids Struct. 8(4), 491-509 (Apr. 1972) 7 refs

Key Words: dynamic analysis, laminates, plates, viscoelastic damping

Based on a new approach to plate theory, procedures are developed for the dynamic analysis of multilayered plates. They provide analytical simplifications and refinements of the physical description which includes the skin effect. The various layers may be anisotropic and each of them may be constituted by thinly laminated materials with stress couples. The damping caused by viscoelasticity is evaluated by a method which brings out the effectiveness of each component material. Detailed end conditions may be imposed at the supports at various points across the thickness. It is shown that a plane strain analysis provides solutions of three-dimensional dynamics for multilayered plates with rectangular, triangular and circular plan forms.

72-930

FREE VIBRATION OF AN UNSYMMETRICAL MULTISTORIED BUILDING MODELED AS A SHEAR-FLEXIBLE CANTILEVER BEAM
Gibson, R.E.; Moody, M.L.; and Ayre, R.S. (Univ. Neb., Dept. Civil Engr., Omaha, Neb.)
Bull. Seismol. Soc. Am. 62(1), 195-213 (Feb. 1972) 13 refs

Key Words: cantilever beams, multistory buildings, natural frequencies, seismic response

A solution is presented for the undamped free vibration frequencies and mode shapes of a multistoried building with unsymmetrical floor plan, modeled as a continuous (distributed parameter), shear-flexible cantilever beam. The beam has constant mass per unit length and a linear distribution of elastic shearing resistance (stiffness) along its length. Three coupled, second-order partial-differential equations describe the rotational and lateral motions. Solution of the equations reveals the presence of "coupling modes", which are dependent on the cross-sectional properties of the beam, and

"τ-modes", which are independent of cross-sectional properties. An exact solution is presented for the coupling modes, and approximate and exact solutions for the τ-modes are obtained. Frequencies are given for different linear variations in elastic resistance, and are presented in dimensionless form. A discrete element analysis is included for purposes of comparison.

72-931

A NUMERICAL CALCULATION BY FINITE DIFFERENCE METHOD FOR FREE VIBRATION PROBLEM OF AXISYMMETRIC SHELLS
Hamada, M. and Miyata, K. (Osaka Univ., Faculty of Engr., Suita, Japan)
Bull. JSME 15(80), 193-201 (Feb. 1972)
6 refs

Key Words: finite difference method, free vibration, numerical methods, shells of revolution

A finite difference method for problems of unsymmetrical bending of axisymmetric shells was presented by B. Budiansky and P.P. Radkowski. By putting the terms of inertia into the equilibrium equations in their paper, a numerical method for free vibration problems of axisymmetric shells of arbitrary forms is proposed in this study, and the validity of this method is checked for shells of various kinds -- circular plates, cylindrical shells, conical shells, spherical shells, and shells of nuclear vessels.

72-932

EQUIVALENT STATISTIC LINEARIZATION OF MECHANICAL VIBRATION SYSTEMS WITH ONE DEGREE OF FREEDOM
Martins, H. (Deutsche Akademie der Wissenschaften zu Berlin, Berlin, Germany)
Maschinenbautechnik 21(1), 27-30 (1972)
8 refs

Key Words: random excitation, statistic linearization, stochastic processes

A statistic linearization method is used to determine the approximate solution of fixed stochastic vibrations of weak nonlinear vibration systems with fixed normal distributed random loading. An example of a vibratory unit with a cubic nonlinear load deflection curve for spring is demonstrated. (In German)

72-933

THREE-DIMENSIONAL AUTOMOBILE OCCUPANT DYNAMICS: A MATRIX APPROACH
Metz, L.D.
Cornell Univ., PhD Thesis (1971) 211 pp

Key Words: collision research, computer programs, equations of motion

A computer-oriented formulation of the equations of motion for connected sets of rigid bodies is investigated. The problem of automobile occupant dynamics modeling is used to demonstrate a situation in which such a set of coupled differential equations is likely to arise. Initially, a coherent discussion of the general problems inherent in the development of rigid body equations of motion in three dimensions is presented. A matrix technique, together with associated simplifying assumptions, is developed for the formulation of such equations for vibratory systems (systems restricted to small motions). The technique is implemented in a computer program.
UM 72-8970

72-934

A GENERAL MATHEMATICAL MODEL FOR THE CLASS IV FLEXTENSIONAL UNDERWATER ACOUSTIC TRANSDUCER
Rutledge, J.R.
N. Car. State Univ., Raleigh, PhD Thesis (1971) 86 pp

Key Words: mathematical models, transducers, underwater sound

A mathematical model for the Class IV or oval flextensional underwater acoustic transducer is developed. The transducer is approximated by combining the models for three distinct problems. The acoustic radiation problem is solved by utilizing a source density formulation for a system of quadrilaterals representing the transducer. The mechanical shell vibration problem is approximated by representing the shell by an analogous framework of bars and joints to represent an arc of varying radius of curvature. Finally, the piezoelectric stack wave equation is solved for the case of an applied arbitrary impedance to represent the shell and acoustic radiation impedances. Analytical data is obtained from a computer program of the mathematical model and compared with experimental values to validate the model.
UM 72-10,105

72-935

THE DYNAMIC RESPONSE OF A VISCOPLASTIC BEAM
Vogel, W.H.
Penn. State Univ., Phd Thesis (1971) 150 pp

Key Words: beams, dynamic response, experimental results, finite element technique, viscoplastic properties

A theoretical and experimental analysis of a viscoplastic beam carrying a tip mass is reported. The prime objective is the inclusion of terms in the constitutive equation to account for strain rate effects in the plastic range. The major portion of the theoretical analysis deals with determining the dynamic response of a viscoplastic beam shock loaded at the base. Since a problem of this type involves a nonlinear partial differential equation with floating boundaries, a finite element technique is employed to obtain a solution. The difference equations for each mass element are derived to take into account changes in geometry of the beam because of large deflections. However, any extensional strains and rotary inertia and shear strain effects are neglected in the analysis. The constitutive equation employed to include strain rate effects in the analysis is of the form

$$EI\dot{K} = \dot{M} + C\,(M - M_{st})$$

where k is curvature; M is dynamic moment; M_{st} is static moment at curvature k; C is material constant; E is modulus of elasticity; and I is area moment of inertia of beam. Dynamic tests are performed on annealed mild (low carbon) and tempered (high carbon) steel cantilever beams to test the validity of the theoretical analysis.
UM 72-9546

72-936

GEAR STIFFNESS AND LOAD DISTRIBUTION OF SPIRAL TOOTHED SPUR GEARS
Ziegler, H. (Aachen, Germany)
VDI-Z 114(2), 120-121 (Feb. 1972)

Key Words: dynamic stiffness, gears

Relations are obtained which allow the determination of the stiffness of a pair of spiral toothed spur gears. With the aid of this relation it is possible to determine the load distribution on spur gears as a function of all factors of influence. In addition, ways to keep the excitation of internal dynamic supplementary forces small in the design stage are given. (In German)

COMPUTER PROGRAMS

(Also see Nos. 933, 990)

72-937

MODIFICATION OF THE GENERAL STRUCTURAL ANALYSIS PROGRAM (SAP) FOR DYNAMIC LOADS
Calif. Univ., Berkeley, Dept. Civil Engr.
NCEL-CR-72.009 (Dec. 1971) 14 pp

Key Words: computer programs, dynamic response, SAP (structural analysis program)

The modification of a general structural analysis program (SAP) to permit analysis for dynamic loads by direct step-by-step integration is described. The theory for the development of the step-by-step method is summarized. The use and limitations of the program are discussed.
AD-736237

DIGITAL SIMULATION

(Also see No. 933)

72-938

DYNAMIC RESPONSE OF ELASTOPLASTIC BEAM-GIRDER SYSTEMS
Wang, S.L. and Gray, H.P.
(Naval Ship R&D Ctr., Washington, D.C.)
Computers and Structures 2(1 and 2), 223-251 (Feb. 1972) 1 ref

Key Words: beams, computer programs, dynamic response

A FORTRAN IV computer program operative on IBM 7090 is described which calculated the dynamic response of elastoplastic beam-girder systems subjected to a uniformly distributed arbitrary forcing function. The ends of the beams and girders may be either simply supported or clamped in any combination. Each member is assumed to possess a bilinear elastoplastic resistance function. The beams are equally spaced within a panel and have identical properties. The program prints out essentially the center deflections of the girder and beam relative to the girder and the dynamic reactions of the beams and the girder. The program is used in the analysis of a continuous stiffened panel with girder supports subjected to a triangular pressure pulse. The results are compared with those based on a simplified analysis which assumes the beam and the girder to be uncoupled single degree-of-freedom members to show the effects of dynamic coupling. Also of particular

interest is the dynamic reaction of the girders obtained from the present analysis as compared with the external loading directly applied over the tributary area of the girder support.

DESIGN INFORMATION
(Also see No. 970)

DESIGN TECHNIQUES

72-939
NOISE CONTROL DESIGN USING SCALE MODEL TESTS
Katra, T.S. and King, D.B. (Carrier Corp., Syracuse, N.Y.)
ASME Paper No. 71-WA/Pwr-7

Key Words: noise reduction, test facilities, turbomachinery

The case history of a noise control project at a large turbomachinery test facility, where the study of scale models is successfully used to circumvent these difficulties to a large extent is described. Performance data is included on a number of piping noise control material combinations, which should be useful in a broad range of problems involving radiation from pipes or similar structures. An outdoor sound level monitor useful in detecting community noise problems is described.

72-940
SPECTRUM COMPATIBLE MOTION FOR DESIGN PURPOSES
Tsai, N.C. (Bechtel Corp., Power and Industrial Div., San Francisco, Calif.)
ASCE, J. Engr. Mech. Div. 98(EM2), 345-356 (Apr. 1972) 5 refs

Key Words: seismic design, spectrum analysis

A practical method is presented to obtain synthetic motions that closely match a reasonable specified design spectrum for a seismic design of important earthquake resistant structures and equipment. The principle of this method is to modify existing motions. For this purpose, a spectrum suppressing technique and a spectrum raising technique are developed. Examples are then given to illustrate applicability to actual structure design.

STANDARDS AND SPECIFICATIONS

SURVEYS
(Also see Nos. 1004, 1025)

72-941
NOISE AND PTC 36
Bannister, R.L. (Westinghouse Electric Corp., Lester, Pa.)
ASME Paper No. 71-WA/PTC-6

Key Words: machinery noise, noise measurement, standards and codes

The progress of the ASME committee for the measurement of industrial sound, PTC 36, is discussed. The committee is concerned with providing a standard method to measure sound pressure level and determine sound power level of machinery by: (1) referring the user to appropriate existing codes and standards that can be used to evaluate specific machinery; (2) determining what additional code requirements should be written; and (3) providing a general procedure for sound measurement when an applicable code is not available. Work in PTC 36 is closely coordinated with activities progressing in the American National Standards Institute and the International Organization for Standardization.

72-942
THE DYNAMIC PERFORMANCE OF ARTICULATED HIGHWAY VEHICLES: A REVIEW OF THE STATE OF THE ART
Dugoff, H. and Murphy, R.W. (Highway Safety Res. Inst., Univ. Mich.)
SAE Preprint No. 710223, 10 pp, 73 refs

Key Words: articulated vehicles, dynamic stability, trailers

The state of theoretical and experimental technology relative to the dynamic performance of articulated highway vehicles is reviewed. The review contains three major sections, corresponding to the traditional breakdown of vehicle performance: directional performance, braking performance, and combined directional and braking performance. A frankly evaluative point of view is taken. Knowledge gaps and unanswered questions are exposed and previous accomplishments and progress are documented. The paper concludes with some recommendations for future research consistent with the findings of the review.

72-943

REVIEW OF THE GROUND MOTION PREDICTION PROBLEM FOR PLOWSHARE UNDERGROUND ENGINEERING APPLICATIONS

Hays, W.W. (Environmental Res. Corp., Las Vegas, Nev.)

Joint Meeting of the American Nuclear Soc., Miami Beach, Fla. (Oct. 1971) 20 pp

Key Words: ground motion, Plowshare projects, underground explosions

Reliable descriptions of the ground motion expected from a Plowshare underground engineering detonation are required (1) to estimate the nature of the forces that will develop in a structure as a consequence of the ground motion and (2) to assess the potential hazard to people and property. The ground motion prediction methodology incorporates both empirical and theoretical analyses and has been developed in terms of the three critical elements of the total wave propagation systems; the source region; the transmission path; and the recording site geology.

NSA 9286

ENVIRONMENTS

ACOUSTIC

(Also see Nos. 939, 941, 961, 969, 1004, 1019, 1025, 1028)

72-944

PROPOSED GAS TURBINE PROCUREMENT STANDARD: SOUND CONSIDERATIONS

Hafer, A.A. and Swensson, G.C. (General Electric Co., Greenville, S.C.)

ASME Paper No. 71-WA/PTC-5

Key Words: noise tolerance, power plants

The increasing emphasis on ecology has intensified the need by users of all types of power equipment to better understand acceptable power plant sound levels. A method of specifying an appropriate sound level for gas turbine power plants representing a balance between being a good neighbor and economics is described.

72-945

PRINCIPLES OF NOISE CONTROL

Ingard, U. (Mass. Inst. Tech., Cambridge Res. Lab. Electronics, Aug. 1971)

Proc. 1971 Intersociety Energy Conversion Engr. Conf., Boston, Mass., 1034-1040, Aug. 1971 6 pp

Key Words: noise reduction, noise tolerance

An overview of the field of noise control is given. After a discussion of the human response to noise, some related criteria and noise regulations are described. Methods of controlling noise are reviewed, and various noise reduction measures based on altering source and transmission path characteristics are considered.

AD-734704

72-946

ACOUSTIC DIFFRACTION BY A PERFECTLY SOFT ANNULAR SPHERICAL CAP

Jain, D.L. and Kanwal, R.P. (Pa. State Univ., Dept. Math., University Park, Pa.)

Intl. J. Engr. Sci. 10(2), 193-211 (Feb. 1972) 8 refs

Key Words: acoustic scattering, rings

The diffraction of time-harmonic axisymmetric acoustic waves by a perfectly soft annular spherical cap is discussed. An integral equation technique is used to solve this three-part boundary value problem. Formulas are presented for the farfield amplitude and the scattering cross section for the case when the incident wave is a plane wave traveling along the polar axis toward the convex surface of the annular cap. By taking appropriate limits the solutions for the corresponding problems for an annular circular disk and the whole spherical cap are derived. Numerical results are presented to display the effects of an opening in the cap in addition to the curvature of the surface on the value of the scattering cross section. The analysis of the paper is further used to evaluate the capacity of an annular spherical cap in free space.

72-947

NOISE IN STEAM POWER STATIONS

Schwarzenbach, A.

Brown Boveri Rev. 59(1), 30-35 (Jan. 1972) 6 refs

Key Words: noise measurement, noise reduction, power plants

Following a review of the effects of noise and methods of measurement, the author describes measurements taken in the machine houses of two power stations and from them derives measures for reducing the noise level.

72-948

EPA ANALYSIS OF NOISE PROBLEMS POINTS WAY TO FUTURE LEGISLATION
Automot. Engr. 80(4), 28-35 (Apr. 1972)

Key Words: engine noise, traffic noise

Report to the President and Congress on Noise takes a close look at transportation and engine noise. A summary of current noise levels, designs, and legislation and the solutions and directions that engineers and legislators will probably be taking over the next 15 years is presented.

RANDOM

(Also see Nos. 922, 923, 1007)

SEISMIC

(Also see Nos. 940, 943, 1008, 1009, 1012, 1013, 1024, 1032)

72-949

STRUCTURAL RESPONSE RESULTS DURING JULY 29, 1970 EARTHQUAKE IN BURMA-INDIA BORDER REGION
Agrawal, P.N. (Sch. of Res. and Training in Earthquake Engr., Univ. Roorkee, Roorkee, U.P., India)
Bull. Seismol. Soc. Am. 62(1), 101-114 (Feb. 1972) 8 refs

Key Words: experimental results, seismic response, structural response

The data from the structural response recorder installations during the July 29, 1970 earthquake in the Burma-India border region are interpreted in terms of structural response results. These results suggest that the nature of the response spectrum curves is dependent on the azimuth of recording. The strike of the fault plane, determined on the basis of the directions of the maximum recorded amplitudes, coincides with the local structural trend and is in conformity with the fault plane solutions for some previous earthquakes in the region.

72-950

CHARACTERISTIC PERIODS OF FUNDAMENTAL AND OVERTONE OSCILLATIONS OF THE EARTH FOLLOWING A DEEP-FOCUS EARTHQUAKE
Nowroozi, A.A. (Lamont-Doherty Geological Observatory of Columbia Univ., Palisades, N.Y.)
Bull. Seismol. Soc. Am. 62(1), 247-274 (Feb. 1972) 28 refs

Key Words: earthquakes, ground motion

The deep-focus earthquake of July 31, 1970 excited a set of fundamental and overtone free oscillations. From analysis of seismograms recorded at Berkeley, California, at an ocean-bottom station in the Pacific, and at Ogdensburg, New Jersey, the fundamental spheroidal oscillations, and fundamental torsional oscillations are identified. The majority of resolved spectral peaks are above the 95 percent confidence level. For some modes with periods less than 300 sec, the observed period at each station differs by up to 2 sec. This path dependency of the period may thus suggest the existence of heterogeneity in the upper mantle. The observed periods are compared to calculated periods for Haddon-Bullen's model HB1 and Derr's model DI-11; for fundamental modes the agreements are good, while differences up to 2 sec exist for some overtone modes.

SHOCK

(Also see Nos. 926, 960, 985, 1026, 1029)

GENERAL WEAPON

72-951

SPECTRAL MATRIX METHOD OF PREDICTING DAMAGE FROM GROUND MOTION
Blume, J.A. and Monroe, R.E.
J.A. Blume and Assoc. Res. Div., San Francisco, Calif., JAB-99-81, (Sept. 1971) 90 refs

Key Words: damage prediction, earthquakes, matrix methods, nuclear explosions, spectral matrix method, underground explosions

Many factors influence structure damage caused by ground motion generated by underground nuclear detonations or earthquakes; such factors include the number and type of structures exposed, the level of ground motion, and the capacity of structures to resist the motion. On a large

scale it is necessary to express the variables statistically and to predict damage levels based upon the joint statistical distribution of the individual variables. The Spectral Matrix Method (SMM) was devised to incorporate all relevant parameters in a unified prediction scheme which takes into account statistical variations of the individual factors. A discussion is presented of the SMM and its application in relation to past and current programs of the U.S. Atomic Energy Commission, Nevada Operations Office.
NSA 9287

PHENOMENOLOGY

COMPOSITE

72-952

WAVE PROPAGATION AND VIBRATIONS IN FIBER-REINFORCED COMPOSITES
Anderson, G.L.
Watervliet Arsenal, Watervliet, N.Y.
TR WVT-7133 (June 1971) 79 pp, 19 refs

Key Words: Bernoulli-Euler method, composite materials, mathematical models, reinforced laminates, vibration response, wave propagation

A mathematical model for unidirectional fiber-reinforced composite materials is developed. This theory is founded on the assumption that the fibers may be treated as Euler-Bernoulli beams. The elastic moduli are assigned numerical values on the basis of recently published data obtained through ultrasonic measuring procedures. Certain boundary value problems formulated in this theory of composites are found to be identical to the corresponding boundary value problems that arise in the theory of couple stresses. The thickness-shear, thickness-stretch, and thickness-twist modes are studied, and the dispersive characteristics of surface waves and Love waves are investigated. All results are compared with the solutions of the same problems formulated within the framework of the so-called effective modulus theory.
AD-734295

72-953

PREDICTION OF SHOCK RESPONSE FOR SEVERAL COMPOSITE MATERIALS
Davis, R.O., Jr. and Wu, J.H. (Eric H. Wang Civ. Engr. Res. Fac., Univ. New Mex., Albuquerque, New Mex.)
Compos. Mater. 6, 126-135 (Jan. 1972) 7 refs

Key Words: composite materials, shock response

Equations governing the response of composite materials to shock loading are presented and used to predict Hugoniot curves for several two-constituent composites called Elkonites. Special attention is given to the transfer of thermal energy between constituents within the shock surface. It is shown that although energy transfer has little effect on the composite Hugoniot, it can change the predicted constituent states remarkably. Hugoniots for several Elkonites are calculated and compared with experimental data.

72-954

STUDIES ON THE DYNAMIC COMPRESSION OF COMPOSITE MATERIALS
Ross, C.A.
Univ. Fla., PhD Thesis (1971) 120 pp

Key Words: composite materials, testing techniques

The basic objective of this study was to fabricate and test under compressive dynamic loading conditions, specimens of specific filament reinforcement in a metal-matrix system in order to establish failure/fracture information and dynamic compressive strength data. Experimental and analytical documentation of results is reported. A tungsten-filament copper-matrix composite was selected. Cylindrical geometry specimens of controlled uniformly arrayed uniaxial filaments were prepared for several filament diameters and volume fractions. Typical experimental results obtained include dynamic stress-strain response and the influence of strain rate, variable filament size, and filament content on the dynamic yield stress of the composite.
UM 72-9718

DAMPING

(Also see No. 976)

72-955

THE DAMPING COEFFICIENT IN WELDED BODIES: A THEORETICAL STUDY
Gianasso, M. (Istituto di Metrologia "G. Colonnetti", C.N.R. Sezione Dinamometrica, Torino, Italy)
Meccanica 6 (4), 241-246 (Dec. 1971) 2 refs

Key Words: damping coefficients, welds

Formulas for damping coefficient increase in welded bodies are obtained. The weld area is assumed to be homogeneous, with different properties from the remaining part of the body. Attention is confined to uniform stress and compression and torsion and flexion vibrations, for simple form bodies and simple bounds.

72-956

THE EFFECTS OF AIR FRICTION ON MISSILE VIBRATIONS
Rubin, C.A.
Kan. State Univ., PhD Thesis (1971) 84 pp

Key Words: beams, friction, missile, mode shapes, natural frequencies

The effects of air friction on the natural frequencies and mode shapes of a missile are investigated. A preliminary treatment is presented to provide a general indication of what these effects might be. The preliminary work treats the missile as a free-free beam which is a paraboloid of revolution with a constant distributed axial load (opposed to the motion of the beam) representing the friction force. This load is assumed to act along the neutral axis of the beam. Longitudinal vibrations are neglected and lateral vibrations are assumed to be small and acting in a plane. A variable end thrust is acting and a directional control parameter is introduced to provide stability. The characteristic equation for the boundary value eigenvalue problem is derived using Frobenius' method. A computer solution is obtained and the final results indicate that a fractional force of the type assumed can have a considerable effect on the vibrational characteristics of the missile. The problem is then investigated more closely with the assumption of a more realistic friction force which is a function of several important parameters.
UM 72-9770

72-957

FLUID DYNAMICS OF VEHICLES TRAVELING IN TUBES OF FINITE LENGTH
Wali, E.I.
Carnegie-Mellon Univ., PhD Thesis (1972) 155 pp

Key Words: aerodynamic excitation, high-speed transportation systems, tube vehicle systems

The dependence of drag forces exerted on a cylindrically shaped vehicle with a streamlined nose and conical tail, which moves coaxially with uniform, linear, relatively low velocity in solid wall tubes of finite length, on the velocity of approach ratio is investigated. The latter is defined as the ratio of the relative velocity of the induced fluid pushed ahead of the vehicle of the absolute velocity of the vehicle. A theoretical analysis is carried out by dividing the fluid flow about the vehicle into near and far flow regions. The fluid pushed ahead and behind the vehicle in the far flow region is treated as steady, fully developed, incompressible, turbulent, one-dimensional flow, defined in terms of a frame of reference fixed at the tube entrance.
UM 72-8075

ELASTIC

(Also see No. 908)

72-958

THE RESPONSE OF AN ELASTIC HALF-SPACE TO THE DYNAMIC EXPANSION OF AN EMBEDDED SPHERICAL CAVITY
Aboudi, J. (Dept. Engr. Sci., Tel-Aviv Univ., Ramat-Aviv, Israel)
Bull. Seismol. Soc. Am. 62(1), 115-127 (Feb. 1972) 14 refs

Key Words: cavity-containing media, elastic half-space, point source excitation

An elastic half-space containing a suddenly loaded spherical cavity is considered. The motion of the half-space, representing waves from the cavity to the surface of the half-space and back again to its interior including the associated Rayleigh waves, is obtained. The solution for the case of a linearly expanding cavity caused by a high explosive charge is also presented, including the case of a half-space of limited strength. These cases exhibit higher values for displacements and stresses as compared with the corresponding nonexpanding case. The applicability of the method of solution to other problems of interest is mentioned.

72-959

NATURAL PERIODS OF TWO-LAYER SYSTEMS
Chen, A.T.F. (Geological Survey, Menlo Park, Calif.)
USGS-GD-71-030 (Sept. 1971) 34 pp

Key Words: impedance, laminates

Linearly elastic, horizontally layered systems subjected to horizontal base motions are considered. A general method for determining natural periods of two-layer systems is presented and the effects of the impedance ratio on the distribution of natural periods of two-layer systems are analyzed. A procedure of extending the results derived for two-layer systems to N-layer systems is proposed and some guidelines for treating embedded thin layers are suggested.
PB-205260

72-960

ONE-DIMENSIONAL SHOCK WAVES IN INHOMOGENEOUS ELASTIC MATERIALS
Chen, P.J. (Sandia Labs., Albuquerque, New Mex.)
Intl. J. Solids Struct. 8(4), 409-414 (Apr. 1972) 9 refs

Key Words: elastic media, shock wave propagation

A differential equation is derived which governs the behavior of the amplitudes of shock waves propagating in inhomogeneous elastic materials without assuming that the regions ahead of the waves are at rest. A number λ, called the critical jump in strain gradient, is shown to exist and the behavior of the amplitude of a shock depends on the relative magnitudes of λ and the jump in strain gradient across the shock. This critical jump in strain gradient depends on the local elastic properties of a given material, the material inhomogeneity and the nature of the strain field ahead of the shock.

72-961

SCATTERING OF SOUND FROM LAYERED HOLLOW ELASTIC CYLINDERS
Tepera, J.E. (Southern Methodist Univ., Dept. Statistics, Dallas, Texas)
TR-111 (Nov. 1971) 79 pp

Key Words: acoustic scattering, cylindrical shells

The scattering of a continuous plane wave by a layered cylinder is investigated through the solution of hyperbolic wave equations and the associated boundary conditions. A basic steel cylinder is assumed to be coated with a single layer of an isotropic linearly elastic material, *e.g.*, copper, nickel, etc., and the resulting farfield scattered pressure patterns are computed considering fluid-filled interior and void interiors. Comparative analyses of the resulting patterns over a wavenumber range of 0.25 to 5.0 show that the mass and elastic moduli of the coating materials are of significant influence, and that there is the presence of an apparent transmission phenomenon. In addition, the thin shell solution to the scattering of a single layer cylinder resulted in magnitude differences in the forward scattered portion for radius-to-thickness (R/t) ratios up to 50 when compared to the two-dimensional elasticity solution.
AD-735859

72-962

INTERACTION OF A SHEAR WALL WITH THE SOIL FOR INCIDENT PLANE SH WAVES
Trifunac, M.D. (Lamont-Doherty Geological Observatory of Columbia Univ., Palisades, N.Y.)
Bull. Seismol. Soc. Am. 62(1), 63-83 (Feb. 1972) 7 refs

Key Words: interaction: structure-medium, mathematical models, seismic excitation

The closed-form solution of the dynamic interaction of a shear wall and the isotropic homogeneous and elastic half-space, previously studied only for vertically-incident SH waves, is generalized to any angle of incidence. It is shown that the interaction equation is independent of the incidence angle, while the surface-ground displacements heavily depend on it. For the two-dimensional model studied, it is demonstrated that disturbances generated by waves scattering and diffracting around the rigid foundation mass are not a local phenomenon but extend to large distances relative to the characteristic foundation length.

72-963

THE MICROPOLAR ELASTIC VIBRATIONS OF A CIRCULAR CYLINDER
Willson, A.J. (Dept. Math., Univ. Leicester, England)
Intl. J. Eng. Sci. 10(1), 17-22 (Jan. 1972) 6 refs

Key Words: circular cylinders, natural frequencies

The fundamental vibrations of a long circular cylinder of a micropolar elastic solid are analyzed and their dispersion equations are discussed. Solutions of these equations, valid in the cases of small cylinder radius or of weak coupling, are obtained explicitly.

FLUID

(Also see Nos. 957, 1001, 1020)

72-964

CERTAIN ASYMPTOTIC RELATIONS FOR THE DYNAMIC MODULI SUPERPOSED OSCILLATORY SHEAR
Bernstein, B.; Huilgol, R.R.; and Tanner, R.I. (IIT, Chicago, Ill.)
Intl. J. Eng. Sci. 10(3), 263-272 (Mar. 1972) 19 refs

Key Words: flexural vibration, fluids

We consider the incompressible BKZ fluid subjected to small in-line and transverse oscillations superposed on steady shear flow. Investigations are made of the asymptotic behavior of the storage and loss moduli at ultrasonic frequencies. Asymptotic formulas for both shear and normal stress moduli are obtained. The relationships between the ultrasonic storage moduli and acceleration waves are also pointed out.

72-965

FLUID SURFACE OSCILLATIONS IN A SHALLOW TWO-DIMENSIONAL BASIN
Byrne, W.J. and Raynor, S. (Gen. Am. Transp. Corp., Niles, Ill.)
Intl. J. Non-Linear Mech. 6(6), 717-727 (Dec. 1971) 3 refs

Key Words: fluids, vibration response

The two-dimensional oscillation of a free liquid surface in a shallow basin of arbitrary cross section is considered. It is assumed that the fluid motion is not influenced by the earth rotation and that the fluid is ideal. Since the linearized equations are not valid in the region of the shoreline, they are used only in the center region of the basin. In the proximity of the shoreline the method of characteristics is used as applied to the nonlinear shallow water equation. The bottom of the basin in this region is approximated by a straight line. Since it is implicitly assumed that the center region drives the shallow wedge at the shoreline, but conversely the shore region does not affect the center region, the usefulness of the solution is confined to the first few cycles only. The analytical solution is checked by applying a numerical method of solution for the entire base. The agreement is satisfactory over the first two cycles.

72-966

PARALLEL FLOW-INDUCED VIBRATION OF FUEL RODS
Chen, S.S. and Wambsganss, M.W. (Argonne Natl. Lab., Argonne, Ill.)
Nucl. Engr. Design 18(2), 253-278 (1972) 37 refs

Key Words: fluid-induced excitation, mathematical models, rods

A mathematical model is proposed to describe the phenomena of parallel flow-induced vibrations of a flexible rod, and a solution is obtained for a rod with arbitrary end conditions; the solution can be used for fixed, hinged, cantilevered, and other elastically supported end conditions. Comparisons between model predictions and flow test data for rods with fixed and cantilevered end conditions show that the model successfully predicts the essential features of the system behavior: (1) the adjacent rods and duct wall may considerably increase the added mass; (2) the fundamental frequency may increase or decrease with flow velocity, depending on the end conditions; (3) the system damping increases with increasing flow velocity, and is attributed to the normal drag force and the coriolis acceleration; (4) the root mean square rod response increases with flow velocity and follows an approximate power function relationship; and (5) the increase in rigidity at the ends tends to reduce the root mean square response.

72-967

STUDY OF HYDRODYNAMICALLY ORIGINATED VIBRATION PROBLEMS ON CERTAIN STRUCTURES OF THE PHENIX BLOCK REACTOR
Lesueur, C.; Milan, D.; and Payan, G. (I.N.S.A. Vibrational Laboratory, Villeurbanne, France)
Nucl. Engr. Design. 18(2), 279-303 (1972) 43 refs

Key Words: nuclear reactors, vibration response

An important source of vibrations in the vessels of a reactor such as the sodium cooled fast French reactor Phenix is the turbulence of the liquid sodium flow. In fact, the random pressure pulsations may excite the natural modes of the structures if they are within the low frequency range. The stability of the vessels and internals of the reactor was ascertained. The vibrational characteristics of the considered structures on mechanical models at the 1/10 or 1/5-scale in the air and in quiet water simulating sodium are measured.

72-968

COMPARISON OF RESULTS OBTAINED FOR THE PROBLEM OF SYMMETRIC FLUID OSCILLATIONS IN TANKS BY THE FINITE ELEMENT METHOD
Schiffner, K. (Deutsche Forschungs-und Versuchanstalt fur Luftund Raumfahrt Arbeitsgruppe Thermoelastik PorzWahn)
DLR FB 71-69 (1971) 69 pp, 15 refs

Key Words: finite difference technique, finite element method, fluids

The problem of symmetric fluid oscillations in axisymmetric tanks is solved by using both a finite difference technique and a finite element method. In order to get comparable computer times, an equal number of nodes and the same bandwidth of matrixes are required for both methods. Since these conditions make a one order higher approximation of the finite difference equations possible as compared to that possible for the displacement functions of finite elements, the finite difference method results in a better approach to the eigenvalue problem.

72-969

SOME PERSPECTIVES AND RECENT FINDINGS IN SHALLOW WATER ACOUSTICS
Urick, R.J. (Naval Ordnance Lab., White Oak, Md.)
NOLTR-71-204 (Nov. 1971) 36 pp

Key Words: measurement techniques, underwater sound

Shallow water acoustics has had in this country a long, though sporadic, history dating back to World War II, when the acoustic mine stimulated feverish activity in the subject. Yet, many aspects of this most difficult branch of underwater acoustics are not understood. Many of its complications are attributable to the temporal and spatial variability of the shallow water medium and its boundaries. For example, the transmission of shallow water sound varies with direction and time at one location and is different at apparently similar locations. Such variations make acoustic prediction difficult, and necessitate on-the-spot measurements at the place and time that data is required. To this end, the author developed and tried out at a number of coastal locations an airborne method of data collection using sonobuoys, explosive sound signals, and simple, portable recording equipment. The transmission results are summarized by loss contour charts showing the transmission environment around a receiving point in shallow water.
AD-735108

INELASTIC
(Also see Nos. 928, 978, 982, 998)

VISCOELASTIC
(Also see Nos. 929, 935)

EXPERIMENTATION

EQUIPMENT

72-970

DYNAMIC TESTING SYSTEMS -- DESIGN GUIDELINES FOR VIBRATION AND SHOCK TESTING FIXTURES
Klee, B.J. and Tustin, W. (Environmental Test Services, Denver, Colo.)
S/V Sound Vib. 6(3), 4, 6, 8, 10, 12 (Mar. 1972) 3 refs

Key Words: shock testing, specifications, test equipment, vibration tests

Ways to specify the dynamic behavior of vibration and shock testing fixtures are suggested. These are intended for the writers of test specifications in defining test fixture performance, and dynamic environmental testing personnel in the interpretation of test specifications.

INSTRUMENTATION
(Also see Nos. 925, 934)

72-971

A NOTE ON CORRECTION OF STRONG-MOTION ACCELEROGRAMS FOR INSTRUMENT RESPONSE
Trifunac, M.D. (Lamont-Doherty Geological Observatory, Columbia Univ., Palisades, N.Y.)
Bull. Seismol. Soc. Am. 62(1), 401-409 (Feb. 1972) 5 refs

Key Words: accelerometers, calibrating

Two methods for accelerometer instrument correction are described: (1) a direct numerical differentiation of recorded accelerograms from which high-frequency digitization errors have been filtered out and (2) an ideal "mathematical accelerometer" with a natural frequency significantly higher than the natural frequency of the recording instrument. Although both methods give good results, the first one is recommended for standard use.

PROCEDURES
(Also see No. 927)

TECHNIQUES
(Also see No. 954)

72-972

DYNAMIC COMPRESSIVE TEST FOR DETERMINING STRESS-STRAIN RELATION OF MATERIAL
Kishida, K. and Senda, K. (Faculty of Engr., Osaka Univ. Suita, Japan)
Bull. JSME 15(79), 25-32 (Jan. 1972) 6 refs

Key Words: dynamic testing, materials

An experimental method of determining the dynamic stress-strain relation of materials and the results of tests on specimens of annealed copper are reported. Remarkable stress drops

after the dynamic yield stress occur in the stress-strain curves of copper in a certain range of strain rates. The stress near the impact end of the specimen should be considered as three-dimensional. In practice, however, if the ratio of specimen diameter to pulse length is reduced sufficiently, uniaxial stress state should be realized, so that this method can be employed to determine the dynamic characteristics of materials. A constitutive equation of metal is proposed from the standpoint of relaxation phenomenon. For a more reasonable description of the dynamic plastic behavior of metals it may be necessary to take the strain history into consideration.

72-973

CONDITIONS FOR SPECTRAL ANALYSIS IN REAL TIME VIBRATION TESTS
Ponzi, U.; Ferroni, R.; and Morelli, G. (Rome Univ.,Sch. Aerosp. Engr., Rome, Italy)
Rept. No. 30 (Aug. 1970) 26 pp

Key Words: spectrum analysis, vibration tests

The possibility of real time spectral analysis during the running of a vibration test of mechanical structures is considered. Accuracy and operation conditions are investigated in order to obtain basic requirements for the instrumentation characteristics. Some specifications concerning the analysis procedures are also suggested.
N72-13891

72-974

ULTRASONIC TESTING AS AN AID IN THE INVESTIGATION OF STEAM BOILERS AND PRESSURE VESSELS
Schlecht, G. (Magdeburg Technische Überwacnung der DDR Inspektion, Magdeburg, Germany)
Maschinenbautechnik 21 (1), 31-34 (1972) 5 refs

Key Words: pressure vessels, testing techniques, ultrasonic tests

The application of ultrasonic testing of steam boilers and pressure vessels to prevent human and economic losses is described. (In German)

72-975

VIBRATION MEASUREMENTS BY THE MOIRE METHOD
Theocaris, P.S. and Paipetis, S.A. (Natl. Tech. Univ., Athens (625), Greece)
J. Phys. E (Sci. Instrum.) 5 (3), 217-219 (Mar. 1972) 8 refs

Key Words: measurement techniques, moire method, optical methods, vibration measurement

A simple and versatile, but also sensitive and accurate method of determining vibration amplitudes is presented. The method consists of observing the slow motion of a moire pattern formed by the image of a signal grating projected onto an identical reference grating, illuminated by stroboscopic light. The pitch of the image of the signal grating can be suitably adjusted to yield an optimum relation between line frequencies of the two gratings. Full control over the sensitivity of the system is therefore possible. The accuracy and resolution of the method are comparable with those of other known methods based on sophisticated vibration measuring equipment.

COMPONENTS

ABSORBERS

72-976

DAMPER DESIGN FROM A STRUCTURAL ENGINEER'S POINT OF VIEW
Chen, J.C. (Jet Propulsion Lab., Calif. Inst. Tech., Pasadena, Calif.)
5th Aerosp. Mech. Symp., pp 59-64 (1971)

Key Words: nonlinear damping, spacecraft

A nonlinear structural analysis, employing the nonlinear damper characteristics obtained from a damper test, is successfully performed on the Mariner spacecraft's solar-panel system and the result is compared with results from a system level spacecraft test in which some solar-plane time dampers bottomed at a certain frequency. The analysis shows that the damper bottoming is attributable to a jump phenomenon that can result when a damper's response is not single-valued at some frequency.
N72-13398

BEAMS, STRINGS, RODS

(Also see Nos. 935, 938, 966)

72-977

ON THE APPLICABILITY OF ONE-DIMENSIONAL NONVISCOUS DYNAMIC PLASTICITY THEORY

Dawson, T.H. (Univ. Va., Charlottesville, Va.)
Intl. J. Mech. Sci. 14(1), 43-48
(Jan. 1972) 16 refs

Key Words: dynamic plasticity

The applicability of one-dimensional nonviscous dynamic plasticity theory to impacting rod problems is examined experimentally using results derived from general three-dimensional and viscous similarity considerations and their corresponding one-dimensional and nonviscous counterparts. When three-dimensional and viscous effects are important, these considerations are found to require a specific response dependent on the ratios of characteristic rod lengths to rod diameters and characteristic striking velocities to rod lengths. Direct examination of experimental impact-duration and impact-displacement data from aluminum and copper rods reveals, however, no such dependence over a wide range of striking velocities and rod lengths. The general applicability of one-dimensional nonviscous dynamic plasticity theory is thus confirmed without recourse to the complex details of the theory.

72-978

FREE VIBRATION OF A SIMPLY SUPPORTED BEAM WITH NONLINEAR MATERIAL PROPERTIES

Iyengar, N.G.R. and Murthy, P.N. (Indian Inst. Tech., Dept. of Aeroanut. Engr., Kanpur, India)
AE-12/1971, 43 pp

Key Words: beams, finite element technique, free vibration, mass beam systems, perturbation method

Free vibrations of a simply supported beam, with and without central mass and with nonlinear material properties, are studied. The material is of the Ramberg-Osgood type. Perturbations and finite element techniques are used to solve the governing equation. The variation of frequency with amplitude is obtained for various values of material parameters. The results indicate that the beam behaves like a soft spring for the type of nonlinearity introduced by the material.
N72-13679

72-979

NONLINEAR DYNAMICS OF CABLES WITH LOW INITIAL TENSION

Leonard, J.W. and Recker, W.W. (Civ. Engr., Ill. Inst. Tech., Chicago, Ill.)
ASCE, J. Engr. Mech. Div. 98(EM2), 293-309 (Apr. 1972) 36 refs

Key Words: cables (ropes), nonlinear response

A method of solution for the three-dimensional nonlinear deployment problem associated with single, lightly-stressed cables is presented. Based on the theory of incremental deformations the governing nonlinear equations are reduced to a system of quasi-linear equations dependent on the prior history of deployment. The solution to the resulting system of equations is obtained by means of a finite element representation valid during some time interval in which the incremental equations approximate the response of the nonlinear system to a stated order of accuracy. The solution is extended to later time intervals by referring additional incremental deformations to a coordinate system based on the new configuration of the cable at the end of the previous time interval. Numerical planar problems are considered for verification and demonstration purposes.

72-980

NONCLASSICAL FORCED MOTION OF STATIONARY AND ROTATING BEAMS WITH TIP MASSES

Robertson, S. (Watervliet Arsenal N.Y.)
WVT-7145 (Sept. 1971) 38 pp

Key Words: beams, forced vibration, mass-beam systems

A formal solution, using Williams' superposition principle, is given for the nonclassical forced motion problems of stationary and rotating beams with tip masses, where the coupling of flexure and torsion is included in the governing equations.
AD-735683

72-981

REDUCTION IN FLUTTER INSTABILITY OF AN ELASTIC BEAM WITH THE RIGID EMPENNAGE IN SUPERSONIC FLOW

Selezov, I.T. and Kovbasa, G.T. (Foreign Tech. Div., Wright-Patterson AFB, Ohio)
FTD-MT-24-97-71 (Nov. 1971) 14 pp
Machine trans. of Gidroaeromekhanika i Teoriya Uprugosti No. 9, pp 29-34 (1970)

Key Words: beams, dynamic stability

The possibility of the expansion of the region of dynamic elastic stability of a finned beam streamlined by a supersonic gas flow is investigated. In order to do this a system of automatic control, which consists of the object of control, measuring elements and actuators, is used.
AD-736487

72-982

IMPULSIVE LOADING OF FULLY CLAMPED BEAMS WITH FINITE PLASTIC DEFLECTIONS AND STRAIN-RATE SENSITIVITY
Symonds, P.S. and Jones, N. (Brown Univ., Div. Engr., Providence, R.I.)
Intl. J. Mech. Sci. 14(1), 49-69 (Jan. 1972) 25 refs

Key Words: beams, dynamic plasticity

A review is given of earlier work on the plastic response to impulsive loading of a beam clamped against end rotations and axial displacements, taking account of small finite transverse displacements and of strain rate dependence of the yield stress. New solutions are derived from rigid-plastic analysis which include both effects in simple approximate ways. Deflections are compared as obtained from these formulas, from experiments described here on mild steel beams and from finite-difference numerical solutions using the M.I.T. rod model with elastic-plastic strain rate sensitive behavior. The significance of agreements observed is discussed.

72-983

WHIRLING OF A STRING AT LARGE ANGULAR SPEEDS -- A NONLINEAR EIGENVALUE PROBLEM WITH MOVING BOUNDARY LAYERS
Wu, C. H. (Univ. Ill., Chicago Circle, Dept. Materials Engr., Chicago, Ill.)
SIAM J. Appl. Math. 22(1), 1-13 (Jan. 1972) 12 refs

Key Words: eigenvalue problems, strings, whirling

Whirling of a string is solved asymptotically for large angular speeds. The asymptotic sequence involved is found to have logarithmic terms. The first few terms of the amplitude-angular speed relations and the mode shapes are obtained explicitly.

BLADES

72-984

LAST-STAGE BLADES OF LARGE STEAM TURBINES
Hohn, A. and Novacek, P.
Brown Boveri Rev. 59(1), 42-53 (Jan. 1972) 5 refs

Key Words: blades, testing techniques, turbine blades

The present article deals with the blades in the last rotating row in large steam turbines, considering them as a machine element. The static and dynamic stresses occurring in service are discussed and their effect on the design of the blades is demonstrated. Some methods of testing which are used in the design of prototypes are explained as they enable blades designed on pure theory to be tested under conditions comparable with those experienced in service, thereby enabling the behavior of the blades in service to be predicted. Nowadays this performance is from time to time checked in service in power stations. Some information is provided regarding test procedures and the results obtained. Future developments in blade construction are discussed.

CONTROLS

72-985

DESIGNS FOR SAFETY: THE MECHANICAL FUSE
Shaw, M.C. (Carnegie-Mellon Univ., Pittsburgh, Pa.)
Mech. Engr. 94(4), 23-29 (Apr. 1972) 10 refs

Key Words: automobile bumpers, collision research, energy absorption

Based on his Thurston Lecture for 1971, the author here discusses two practical designs for absorbing the kinetic energy in an automotive crash. Both devices safely and irreversibly convert the unwanted energy to heat by metalworking processes performed on replaceable "fuses" made of inexpensive pieces of tubing.

GEARS
(Also see No. 936)

MECHANICAL
(Also see No. 932)

72-986
ON SUBHARMONIC OSCILLATIONS OF A PENDULUM
Cheshankov, B.I.
Appl. Math. Mech. 35(2), 301-306 (1971)
(Engl. Transl. of Prikladnaya Matematika i Mekhanika 35(2), 343-348 (1971))
12 refs

Key Words: oscillations, pendulums

Subharmonic oscillations of a pendulum excited by horizontal oscillations of its suspension in the case of simple harmonic excitation are investigated. The motion of a mathematical pendulum excited by oscillations of its point of suspension has been studied by many authors. The influence of the vertical oscillations of the point of suspension is ordinarily considered but there are papers devoted to the influence of the horizontal oscillations and of oscillations of more general form. A supplement by Struble to existing asymptotic methods in the theory of nonlinear oscillations is used herein.

MEMBRANES

72-987
ISOPERIMETRIC INEQUALITY FOR SOME EIGENVALUES OF AN INHOMOGENEOUS, FREE MEMBRANE
Bandle, C. (Dept. Math., Stanford Univ., Stanford, Calif.)
SIAM J. Appl. Math. 22(2), 142-147 (Mar. 1972) 6 refs

Key Words: eigenvalue problems, membranes

Szegö's inequality concerning the second eigenvalue of a homogeneous, free membrane is extended to the case of an inhomogeneous free membrance. With the help of a variational principle and the conformal mapping technique, upper bounds are constructed for the sum $1/\mu_2 + 1/\mu_3$, where μ_2 and μ_3 denote the second and third eigenvalues. These bounds depend only on the total mass of the domain and on a simple expression involving the mass distribution and its logarithm.

72-988
DYNAMIC BEHAVIOR OF CYLINDRICAL MEMBRANES
Dickey, R.W. (Univ. Wis., Madison, Wis.)
Intl. J. Nonlinear Mech. 6(6), 729-734 (Dec. 1971) 15 refs

Key Words: cylindrical membranes, dynamic response, membranes, nonlinear theories

An often encountered difficulty in nonlinear membrane theories, is that of discussing static or dynamic solutions to the nonlinear membrane equations when the equilibrium tensions are small. In this paper a theory of cylindrical membranes is formulated, which is essentially the dynamic equivalent of the Bromberg-Stoker theory. It is shown that a cylindrical membrane may develop compressions in the course of its vibration, unless the axial equilibrium tension exceeds a definite positive value. In addition, a short discussion is given of the dynamic behavior of cylindrical membranes.

PLATES AND SHELLS
(Also see Nos. 916, 917, 918, 929, 931, 994)

72-989
ON THE THREE-DIMENSIONAL PROBLEM OF MAGNETOELASTIC PLATE VIBRATIONS
Ambartsumian, S.A.; Bagdasarian, G.E.; and Belubekian, M.V.
Appl. Math. Mech. 35(2), 184-195 (1971)
(Engl. Transl. of Prikladnaya Matematika i Mekhanika 35(2), 216-228 (1971)) 6 refs

Key Words: magnetoelastic vibrations, plates

The problem of investigating the magnetoelastic vibration of an electrically conducting plate in a magnetic field reduces to the combined solution of the magnetoelasticity equations in the domain occupied by the plate (interior problem), and the electrodynamics equations of the rest of the domain of the space under consideration (exterior problem). An attempt is made to determine the magnetic field of a thin plate of finite conductivity by the asymptotic integration of the combined equations of magnetoelasticity for the domain occupied by the plate. Jointly considering the exterior and interior problems, the magnetoelastic vibrations of a thin plate of finite conductivity are investigated. Some magnetoelasticity hypotheses are formulated for a plate of finite conductivity.

72-990

A PROGRAM FOR THE NONLINEAR STATIC AND DYNAMIC ANALYSIS OF ARBITRARILY LOADED SHELLS OF REVOLUTION

Ball, R.E. (Naval Postgraduate Sch., Monterey, Calif.)

Computers and Structures 2(1 and 2), 141-162 (Feb. 1972) 17 refs

Key Words: computer programs, dynamic response, shells of revolution

A digital computer program for the geometrically nonlinear static and dynamic response of arbitrarily loaded shells of revolution is described. The governing partial differential equations are based upon Sanders' nonlinear thin shell theory for the conditions of small strains and moderately small rotations. The governing equations are reduced to uncoupled sets of four linear, second order, partial differential equations in the meridional and time coordinates by expanding the dependent variables in a Fourier sine or cosine series in the circumferential coordinate and treating the nonlinear modal coupling terms as pseudoloads. The derivatives with respect to the meridional coordinate are approximated by central finite differences, and the displacement accelerations are approximated by the implicit Houbolt backward difference scheme with a constant time interval. At every load step or time step each set of difference equations is repeatedly solved, using an elimination method, until all *solutions* have converged. Results from the program are compared to previously published data for several problems, and the versatility, efficiency, and limitations of the program are candidly evaluated.

72-991

ON THE DENSITY OF EIGENVALUES IN PROBLEMS OF STABILITY OF THIN ELASTIC SHELLS

Bendich, N.N. and Kornev, V.M.

Appl. Math. Mech. 35(2), 323-328 (1971) (Engl. transl. Prikladnaya Matematika i Mekhanika 35(2), 364-368 (1971)) 11 refs

Key Words: eigenvalue problems, natural frequencies, shells

Asymptotic estimates are determined for the density of eigenvalues. The existence of points of concentration of the eigennumbers is established. Results for the natural frequencies of shells and the eigenvalues in stability problems are compared. Conditions are written down for the solvability of the linear equation describing the stability in the presence of small perturbations.

72-992

NATURAL FREQUENCIES AND MODES OF TAPERED SKEW PLATES

Chopra, I. and Durvasula, S. (Natl. Aeronaut. Lab., Bangalore 17, India)

Intl. J. Mech. Sci. 13(11), 935-944 (Nov. 1971) 6 refs

Key Words: mode shapes, natural frequencies, skew plates, variable cross section

The vibration of simply supported skew plates having a linear variation in thickness in one direction is considered. Approximate analysis is made by using Lagrange's equations employing the double Fourier sine series in oblique coordinates to represent the deflected surface. Natural frequencies are obtained for rhombic plates for several ranges of thickness variation and skew angle. The nodal patterns plotted for a few typical configurations show interesting metamorphoses with variation in thickness and skew angle.

72-993

ON THE LOWER PORTION OF THE SPECTRUM OF NATURAL AXISYMMETRIC VIBRATIONS OF A THIN ELASTIC SHELL OF REVOLUTION

Khar'kova, N.V.

Appl. Math. Mech. 35(3), 397-404 (1971) (Engl. Transl. PMM 35(3), 438-445 (1971)) 8 refs

Key Words: boundary layer excitation, eigenvalue problems, natural frequencies, shells of revolution

Conditions are presented for which the lower part of the spectrum of the membrane problem consists of an infinite series of eigenvalues converging to the lower bound of the continuous spectrum. It is shown that boundary layer theory is applicable to this portion of the spectrum and the first approximation is obtained for the eigenvalues.

72-994

DYNAMIC ELASTIC BUCKLING OF STRINGER-STIFFENED CYLINDRICAL SHELLS UNDER AXIAL IMPACT

Maymon, G. and Singer, J. (Scientific Dept., Israel Ministry of Defense)

Israel J. Tech. 9(6), 595-606 (1971) 12 refs

Key Words: cylindrical shells, dynamic buckling, stiffened cylinders

The dynamic elastic buckling of stringer-stiffened cylindrical shells subjected to axial

impact has been studied by a small deflection theory which is an extension of that developed by Lindberg and Herbert (1966) for unstiffened cylindrical shells. The analysis applies only to closely spaced stringers which can be considered "smeared" and to cylinders of sufficient length to permit buckling within an axial compression wave. It was found that there is an optimum stiffener geometry for minimum amplification of imperfections.

72-995

HIGH FREQUENCY VIBRATIONS OF PIEZOELECTRIC CRYSTAL PLATES
Mindlin, R.D. (Columbia Univ., Dept. Civ. Engr. and Engr. Mech., New York, N.Y.)
TR-8-TR-22 (Jan. 1972) 27 pp

Key Words: equations of motion, piezoelectric materials

Two-dimensional equations of motion of piezoelectric crystal plates are obtained by retaining early terms of power series expansions of the mechanical displacement and electric potential in a variational principle for the three-dimensional equations of piezoelectricity.
AD-735956

72-996

WAVE SURFACES DUE TO IMPACT ON ANISOTROPIC PLATES
Moon, F.C. (Aerosp. and Mech. Sci. Dept., Princeton Univ., N.J.)
Compos. Mater. 6, 62-79 (Jan. 1972)
12 refs

Key Words: anisotropic properties, plates, shock excitation, transverse impact

The stress waves induced in anisotropic plates by transverse, short-duration impact forces are examined. The anisotropy is related to the layup angles of the fibers of a fiber composite laminated plate. Using a modification of Mindlin's approximate theory of plates, the author shows that both extensional and bending waves are generated by transverse impact. The magnitudes of the wave velocities in different directions are calculated for graphite fiber-epoxy matrix plates for various layup angles. The shapes of the wave fronts or wave surfaces caused by point impact are also presented for the cases mentioned.

72-997

DYNAMIC RESPONSE OF A RIGID CIRCULAR PLATE ON A KERR TYPE FOUNDATION MODEL
Rades, M. (Polytechnic Inst., Bucharest, Romania)
Intl. J. Engr. Sci. 9(11), 1061-1073 (Nov. 1971) 11 refs

Key Words: circular plates, dynamic response, Kerr type foundation, mathematical models

The response of a Kerr type foundation model subjected to a rigid circular plate is considered, for both static and dynamic loading conditions. The coefficient of subgrade reaction is expressed in terms of foundation moduli and radius of the plate. The steady state vertical vibrations of a rigid circular plate resting on such a foundation are studied using an equivalent lumped parameter system. Pressure distributions under the plate are presented for different exciting frequencies and foundation parameters.

72-998

IMPULSIVE LOADING OF RECTANGULAR PLATES WITH FINITE PLASTIC DEFORMATIONS
Sureshwara, B.; Lee, L.H.N.; and Ariman, T. (Notre Dame Univ., Col. Engr. Notre Dame, Ind.)
THEMIS-UND-71-5 (Nov. 1971) 44 pp

Key Words: rectangular plates, shock response

The response of inelastic rectangular plates to impulsive loadings is investigated. The effects of strain hardening and strain rate sensitivity of the material are taken into consideration. A variational principle in dynamics of inelastic bodies subject to finite deformation is used to determine the deformation process of the plate. A sandwich plate idealization is employed. The accuracy of the numerical solution is evaluated by comparing it with the existing analytical and experimental results. The results indicate that this method is adequate for determining the dynamic behavior of inelastic rectangular plates at relatively large deformations.
AD-734675

72-999

ON THE VIBRATIONS OF ROTATING CIRCULAR CYLINDRICAL SHELLS WITH FREELY SUPPORTED ENDS
Wang, S.
Rutgers Univ., N.J., PhD Thesis (1971) 106 pp

Key Words: cylindrical shells, free vibration

A theoretical analysis of the free vibration characteristics of a thin cylindrical shell, with freely supported ends, rotating about its axis with a constant angular velocity is presented. The equations of motion are derived on the basis of a linearized bending theory of shells subjected to a general state of initial stress. By this approach, some apparent contradictions involving fundamental principles of mechanics present in previous investigations are eliminated. The effects of rotation, including those of centrifugal and coriolis forces, on the natural frequencies, mode shapes, and displacement amplitude ratios are considered and evaluated for all three vibrational modes of each nodal pattern. The maximum rotational speed for which the shell remains elastic is determined. Accurate closed-form expressions for the natural frequency and nodal relation velocity of the flexural modes are derived, and their accuracy and range of application are also examined. The results are compared with previous solutions.
UM 72-9687

RINGS

72-1000

CHARACTERISTIC FREQUENCIES OF A SYMMETRICALLY LOADED RING
Charnley, T. and Perrin, R. (Physics Dept., Loughborough Univ. Tech., U.K.)
Acustica 25(4), 240-246 (Oct. 1971) 4 refs

Key Words: natural frequency, rings, vibration measurement

Measurements of the natural frequencies of vibration of a uniform thin circular ring in the flexural radial and axial modes are reported. These vibrations occur in degenerate doublets whose behavior under perturbations in the form of equal loads attached to the ring at the vertexes of inscribed regular nth order polygons is investigated experimentally, and compared with the predictions of "selection rules" previously obtained by group theoretical techniques. The results show a convincing correlation with the predictions of the rules.

STRUCTURAL

72-1001

CIRCULAR CYLINDER OSCILLATING ABOUT A MEAN POSITION IN INCOMPRESSIBLE MICROPOLAR FLUID
Rao, L.S.K. and Rao, B.P. (Dept. Math., Region Engr. Col., Warangal 4 (A.P.), India)
Intl. J. Engr. Sci. 10(2), 185-191 (Feb. 1972) 3 refs

Key Words: cylindrical shells, submerged structures

The motion of a micropolar incompressible fluid arising from the rectilinear oscillation of a circular cylinder is examined. The velocity, microrotation, stress and couple stress components are expressed in terms of the modified Bessel functions with complex arguments. The force on the cylinder is obtained. It is found that it does not experience any couple.

SYSTEMS

ABSORBER

72-1002

TEST RESPONSE OF IMPROVED SAFETY AIR CUSHION SYSTEM
Mazelsky, B. (ARA, Inc., West Covina, Calif.)
Nov. 1971, 44 pp

Key Words: automobiles, collision research, safety restraint systems

The report presents the results of two tests performed using the ARA, Inc., passive restraint air bag system; a static inflation test and a dynamic crash test. These tests demonstrate the system's ability to provide protection to the front passenger of an automobile during a frontal impact of 30 mph and at the same time have a significantly reduced noise level. Two systems are compared for adequate protection to the front passenger. One system demonstrates the desired controlled directional response by contacting and restraining the upper torso of the occupant with the center portion of the air bag cushion.
PB-205850

ACTIVE ISOLATION

72-1003

ACTIVE VIBRATION ISOLATION FOR AIRCRAFT SEATING
Calcaterra, P.C. (Barry Div., Barry Wright Corp., Watertown, Mass.)
S/V Sound Vib. 6(3), 18-23 (Mar. 1972) 26 refs

Key Words: aircraft seating, vibration isolators

Experience and laboratory experiments indicate that seated personnel are particularly susceptible to vibration excitation in the 4 to 20 Hz region, which encompasses the fundamental upper torso resonance in addition to eyeball and head-on-shoulder resonances of the human body. This article discusses the general nature of human vibration factors and describes the application of active vibration isolators for protecting aircraft pilots from severe dynamic environments.

AIRCRAFT

(Also see Nos. 919, 1003)

72-1004

TRENDS IN AIRCRAFT NOISE ALLEVIATION
Morgan, Y.G. (Natl. Aeronaut. and Space Admin., Langley Res. Ctr., Langley Sta., Va.)
Vehicle Tech. for Civ. Aviation (1971) p 301-315

Key Words: aircraft noise, noise reduction

The principal sources of aircraft noise are engines, rotors and propellers, boundary layers, and the sonic boom. Elimination or reduction of noise at the source is the most obvious approach to noise abatement. New operational procedures, such as the steep approach, reduce engine noise by operating at reduced power while also lengthening transmission paths of the noise through the atmosphere so that less noise reaches airport communities. Flight or ground structures can also be used to shield passengers or the public from the noise that cannot be eliminated at the source. In any event, a problem exists when noise reaching a receiver causes annoyance (people) or degraded performance (people or structures). The effects of noise on people and structures and noise reduction from rotary-wing vehicles are discussed.
N72-13012

72-1005

AUTOMATED PRELIMINARY DESIGN OF SIMPLIFIED WING STRUCTURES TO SATISFY STRENGTH AND FLUTTER REQUIREMENTS
Stroud, W.J.; Dexter, C.B.; and Stein, M. (Natl. Aeronaut. and Space Admin., Langley Res. Ctr., Langley Sta., Va.)
NASA-TN-D-6534 (Jan. 1972) 138 pp

Key Words: aircraft wings, flutter, mathematical models, minimum weight design

A simple structural model of an aircraft wing is used to show the effects of strength (stress) and flutter requirements on the design of minimum-weight aircraft-wing structures. The wing is idealized as an isotropic sandwich plate with a variable cover thickness distribution and a variable depth between covers. Plate theory is used for the structural analysis, and piston theory is used for the unsteady aerodynamics in the flutter analysis. Mathematical programming techniques are used to find the minimum-weight cover thickness distribution which satisfies flutter, strength, and minimum gage constraints.
N72-13887.

BRIDGES

72-1006

FREE IN-PLANE VIBRATION OF CIRCULAR ARCHES
Veletsos, A.S.; Austin, W.J.; Lopes Pereira, C.A.; and Wung, S.J. (Dept. Civ. Engr., Rice Univ., Houston, Tex.)
ASCE, J. Eng. Mech. Div. 98(EM2), 311-329 (Apr. 1972) 21 refs

Key Words: arches, mode shapes, natural frequencies

A comprehensive numerical study is made of the natural frequencies and modes of vibration of hinged and fixed, uniform, circular arches vibrating in their own plane. Based on a study of modal patterns and the distribution of the associated strain energies, it is shown that the vibrational modes may be almost purely flexural as in a beam, or almost purely extensional either as in a ring executing a uniform in-and-out motion or as in a bar in axial vibration, or the extensional and flexural actions may be strongly coupled. The conditions of occurrence of each type of behavior are defined, and simple approximate formulas are presented with the aid of which the free vibrational characteristics of such systems may be estimated readily. The approach used to derive the approximate formulas

may also be applied to arches with other profiles, boundaries, and properties. The study is based on a theory which accurately considers all effects except rotatory inertia and shearing deformation.

72-1007

BRIDGE BEAM RESPONSE TO SIMULATED HIGHWAY LOADS
Wagner, F.P., Jr.
Tex. Tech. Univ., PhD Thesis (1971) 108 pp

Key Words: bridges (structures), dynamic response, mathematical models

This investigation utilized simulation of load arrivals and a beam response equation to relate bridge response to random traffic flow. The midspan deflection of the beam is computed at discrete sampling time increments in the digital computer and the statistical characteristics of the response are recorded. When the time span of the simulation run is complete a summary of the response is printed. The frequency of response and expected rate of threshold crossing are the statistical records used. The response equation utilized considers a concentrated force (zero mass) moving at a constant velocity across a simple beam. The elastic and mass properties of the beam are constant.
UM 72-10,379

BUILDING

72-1008

SEISMIC RESPONSE EFFECTS ON EMBEDDED STRUCTURES
Anderson, J.C. (Sargent and Lundy Engrs., Chicago, Ill.)
Bull. Seismol. Soc. Am. 62(1), 177-194 (Feb. 1972) 15 refs

Key Words: finite element technique, interaction: structure-medium, seismic response, underground structures

The finite element method is used to evaluate the effect of soil-structure interaction on the seismic response of embedded structural systems. The system considered is representative of a nuclear power station located on a multilayered, elastic medium. Effects of structure stiffness, rock, motions, and soil properties are considered. Results are presented in terms of foundation acceleration spectra. Results show that the inclusion of soil-structure interaction can amplify the free field spectrum in certain frequency ranges while suppressing it in others. It is suggested that an uncoupled soil-structure model together with a rocking spring and a modified design spectrum be used to evluate the seismic design requirements of nuclear power stations located on various soil-sites.

72-1009

EARTHQUAKE RESPONSE OF BUILDING FOUNDATION SYSTEMS
Bielak, J. (Calif. Inst. Tech., Earthquake Engr. Res. Lab., Pasadena, Calif.)
EERL-71-04 (1971) 153 pp

Key Words: interaction: structure-medium, multistory buildings, seismic excitation

An investigation on the dynamics of soil-structure interaction is reported. The forced horizontal, rocking and vertical harmonic oscillations of a rigid disk perfectly bonded to an elastic half-space are studied. The effect of a deformable foundation on the response of a building to earthquake excitation is studied. The base of the building is idealized as a rigid circular plate attached to the surface of the ground, and the soil is modeled by homogeneous, isotropic, elastic half-space. The equations of motion of an n-story building-foundation system are solved by both direct and transform methods. For the special case of a single-story building on a flexible foundation, approximate explicit formulas are obtained for the effective natural frequency, critical damping ratio, and the amplitude of the modified excitation in terms of the dimensionless parameters which govern the behavior of the system.
PB-205305

72-1010

MEASUREMENT OF THE NATURAL FREQUENCIES OF THE WALLS OF BUILDINGS SENSITIVE TO SONIC BOOM
De Tricaud, P. (Sci. and Tech. Centre on Building, Paris, France)
RAE-Lib-Trans.-1589 (1971) 38 pp

Key Words: sonic boom, structural elements, walls, windows

A method of measuring the dynamic characteristics and natural frequencies of internal dividing walls and of window areas susceptible to sonic boom damage is described. It is shown that the results from the same type of dividing wall can vary by a large factor depending upon how the wall material is manufactured and on how the interior wall is attached to the main structure. The measured results are compared with those calculated for various types of internal walls

and show a reasonable degree of agreement between calculated and measured values, provided that the physical constants of the materials are known with some accuracy.
N72-13873

72-1011

MULTISTORY BUILDING RESPONSE DETERMINED FROM GROUND VELOCITY RECORDS
Douglas, B.M. and Weir, P. (Civ. Engr. Dept., Univ. Nev., Reno, Nev.)
Bull. Seismol. Soc. Am. 62(1), 357-367 (Feb. 1972) 14 refs

Key Words: experimental results, multistory buildings, seismic excitation, structural response

Basement- and roof-level velocity records obtained in a 22-story reinforced concrete building in Reno, Nevada, for the nuclear event FAULTLESS are presented. Analysis of these records indicates that the fundamental period of the building in the E-W direction for small excitations is 1.79 sec. Response calculations are made from an accelerogram, which is produced from the digitized basement-velocity record by filtering out the high-frequency noise and numerically differentiating the filtered result. Also, the equations of motion are recast in terms of absolute motion so that the response of the structure can be obtained by using a linear combination of the ground velocity and displacement records as the forcing function. The ground displacement used in this treatment was obtained by integration of the velocity trace, corrected for baseline errors. These two methods give virtually identical results and agree well with the measured roof motion.

72-1012

STATISTICAL CORRELATION OF OBSERVED GROUND MOTION WITH LOW-RISE BUILDING DAMAGE: PROJECT RULISON
Farhoomand, I. and Scholl, R.E. (John A. Blume and Assoc. Res. Div., San Francisco, Calif.)
JAB-99-87 (Sept. 1971) 67 pp

Key Words: buildings, damage prediction, ground motion, statistical analysis

A statistical study conducted using the observed *ground motion and structure* damage data obtained from Project Rulison is described. The statistical analysis leads to identifying the ground motion characterization which best represents the damage potential of ground motion for low-rise buildings. A statistical model for predicting damage is presented. This model relates ground motion intensity to three damage prediction parameters: number of complaints, percentage of building damaged, and damage repair cost. A simple procedure for the application of the model to practical cases is discussed. The vector of the two horizontal components or response spectrum acceleration is determined to best represent the damage potential of ground motion for low-rise buildings.
NSA 9288

72-1013

RESPONSE SPECTRUM SOLUTION FOR EARTHQUAKE ANALYSIS OF UNSYMMETRICAL MULTISTORIED BUILDINGS
Gibson, R.E.; Moody, M.L.; and Ayre, R.S. (Dept. Civ. Engr., Univ. Nebr., Omaha, Neb.)
Bull. Seismol. Soc. Am. 62(1), 215-229 (Feb. 1972) 10 refs

Key Words: cantilever beams, modal analysis, multistory buildings, seismic response

Modal analysis and response spectra are used to develop an approximate method for earthquake analysis of unsymmetrical multistoried buildings modeled as shear-flexible cantilever beams. The beam has constant mass per unit length and a linear variation of elastic shearing resistance along its length. Existing modal solutions are used and response spectra for two horizontal earthquake components are included in the analysis. Solutions for a typical building are presented and compared with an exact form of solution.

72-1014

DYNAMIC ANALYSIS OF COUPLED SHEAR WALLS AND SANDWICH BEAMS
Skattum, K.S. (Calif. Inst. Tech., Earthquake Engr. Res. Lab., Pasadena, Calif.)
EERL-71-06 (May 1971) 192 pp

Key Words: free vibration, natural frequencies, sandwich beams, walls

A study is made of the free vibration of planar coupled shear walls, a common lateral load-resisting configuration in building construction where two walls are coupled together by a system of discrete spandrel beams. The differential equations and boundary conditions are obtained by the variational method, and by assuming that the spandrels can be replaced by a continuous system of laminae, or small beams. Natural frequencies and mode shapes are determined, the importance of including vertical displacement in the analysis is discussed, and a

study of the effect of neglecting the vertical inertia term is given. These cases are illustrated with graphs and with one specific example. Investigations are also made of the asymptotic behavior of the system as the spandrels become weak, as they become stiff, and as the frequencies become large. Finally, the theory of sandwich beams is presented and compared to that for coupled shear walls.
PB-205267

CONSTRUCTION
(Also see No. 1015)

EARTH

72-1015

COMPARISON OF COMPUTED AND MEASURED DYNAMIC RESPONSE OF MONTICELLO DAM
Roehm, L. H. (Bur. Reclamation, Engr. and Res. Ctr., Denver, Colo.)
REC-ERC-71-45 (Dec. 1971) 16 pp

Key Words: dams, seismic response, vibration tests

Forced vibration tests were made on Monticello Dam to obtain natural frequencies, mode shapes, and damping ratios for the structure. The analytical method used to determine computed values for natural frequencies and mode shapes so that experimental and computed data can be compared is outlined. Also compared are crest deflections determined from accelerations measured during the tests with computed deflections. The results of the investigation indicate that the analytical method is satisfactory for estimating earthquake loadings for concrete arch dams where the loadings include the effects of structural resonance.
PB-205410

72-1016

RANDOM FATIGUE IN EARTHQUAKE ENGINEERING
Tang, J.
Univ. New Mex., PhD Thesis (1971) 73 pp

Key Words: earthquake damage, fatigue life, random excitation, statistical analysis

A method for the computation of the statistics of the cumulative low-cycle fatigue damage of structures subjected to random excitation is presented. In particular, the expected fatigue life of a structure subjected to white noise excitation is given in closed form. Moreover, for earthquake type excitation, the expected fatigue damage is computed numerically by using several types of simulated earthquakes. A structural design concept of a fatigue damage factor is suggested.
UM 72-8374

MECHANICAL

72-1017

DYNAMICS OF MACHINES (COLLECTION OF ARTICLES)
Kozhevnikova, S.N. (Foreign Tech. Div., Wright-Patterson, AFB, Ohio)
FTD-MT-24-33-71 (Oct. 1971)

Key Words: dynamic response, machinery, vibration response

The collection includes articles on dynamic problems of contemporary machine theory. The following topics are covered: general questions of dynamics of machines; vibrations; the dynamics of vibration and vibropercussion systems of the vibroconveyer, electropneumatic hammers, etc.; the dynamics of revolving rotors where questions have been considered regarding stability of motion, hydrodynamic theory of lubrication of bearings, and power analysis; and the dynamics of specific mechanisms and machines such as rolling mills, automatic lathers, draw-gear devices, etc.
AD-736474

72-1018

REPRESENTATION AND PROGRAMING OF THE TORQUE CHARACTERISTIC OF A HIGH-PRESSURE BALING PRESS
Kühlborn, H. (Braunschweig-Voelkenrode)
VDI-Z 114 (1), 44-48 (Jan. 1972) 3 refs

Key Words: baling presses, presses, simulation

The complete solution of a differential equation or a system of differential equations, respectively, can be only determined if the terms are taken into account which represent the disturbing influences. In the case of driving systems, these terms are predominantly given by the driving and braking torques. Computer aided vibration investigations require that the calculation circuits are programed according to these disturbance terms. In this manner it is also possible to simulate the characteristic of the crankshaft torque in a high-pressure baling press. This simulation allows for calculating critical speeds the values of which are in good agreement with

those values which will be obtained by means of a Fourier analysis of the torque characteristic. A calculation example provides hints on how similar characteristics can be determined approximately. (In German)

METAL WORKING AND FORMING

72-1019

ANALYSIS AND CONTROL OF WOOD PLANER NOISE
Stewart, J.S. and Hart, F.D. (N. Car. State Univ., Raleigh, N. Car.)
S/V Sound and Vib. 6(3), 24-27 (Mar. 1972)

Key Words: machinery noise, noise reduction

The causes of wood planer noise are analyzed and possible means of noise control are outlined. The sources of noise generation and the factors influencing the radiation of sound are considered. Possible solutions including mechanical redesign of new machines and short-term solutions applicable to existing machines are presented.

PACKAGE

(Also see No. 968)

72-1020

NATURAL FREQUENCIES OF VISCOUS LIQUIDS IN RECTANGULAR TANKS
Scars, G. (Istituto di Idraulica della Facolta di Ingegneria, Universita di Genova, Italy)
Meccanica 6(4), 223-232 (Dec. 1971) 8 refs

Key Words: fluid filled containers, fluids, natural vibration, tanks (containers)

A procedure for calculating natural oscillating frequencies of viscous liquids in rigid rectangular tanks is suggested together with diagrams for obtaining the values by means of dimensionless coefficients. Experimental results are compared with the theoretical ones and are found to be in good agreement.

PRESSURE VESSELS

(Also see Nos. 966, 974)

PUMPS, TURBINES, FANS, COMPRESSORS

(Also see No. 968)

72-1021

NOISE IN MACHINE HYDRAULIC SYSTEMS
Bashta, T.M.
Rus. Engr. J. 50(6), 33-38 (1971)
(Engl. transl. of Vestnik Mashinostroeniya by Production Engr. Res. Assoc.)

Key Words: machinery noise

The operation of displacement pumps and similar equipment in machine hydraulic systems is accompanied by noise, the level and frequency range of which, in the majority of cases, may serve as indexes of the quality of design and manufacture of the equipment. In particular the noise index of a pump has such conformity that it is possible, by its very characteristics, to evaluate a pump qualitatively (in addition to existing methods of inspection of hydraulic and mechanical parameters), both in regard to output and operation. Certain types of noise and certain noise level values make it possible to detect certain defects in the working of the pump, which could become so dangerous as to impair its operation.

72-1022

EFFECTS OF HIGH-PRESSURE RING SEALS ON PUMP ROTOR VIBRATIONS
Black, H.F. and Jenssen, D.N. (Heriot-Watt Univ., Edinburgh, Scotland)
ASME Paper No. 71-WA/FE-38

Key Words: lateral response, rotors

The bearing action of fine clearance spaces greatly affects the lateral vibrations response and stability of pump rotors. The authors summarize the theoretical determination of the hybrid dynamic bearing properties of high-pressure annular controlled leakage seals and compare, with good agreement, theoretical predictions to dead load and vibrations tests on a flexible rotor incorporating ring seals.

RAIL

72-1023

DYNAMIC INTERACTIONS BETWEEN MOVING LOADS AND THEIR SUPPORT STRUCTURES, WITH APPLICATIONS TO AIR CUSHION VEHICLE-GUIDEWAY DESIGN
Wilson, J. F. (Duke Univ., Dept. Civ. Engr., Durham, N. Car.)
FRA-RT-72-27 (Nov. 1971) 207 pp

Key Words: dynamic response, ground effect machines, high-speed ground transportation, interaction: vehicle-guideway, mathematical models

Several realistic models of vehicle-guideway systems are formulated and evaluated. Emphasis is on the dynamic responses (deflections and bending moments) of guideways designed for air cushion vehicles with speeds up to 300 mph. Design optimization for passenger comfort is discussed.
PB-205325

REACTORS

(Also see No. 967)

72-1024

ASEISMATIC DESIGN OF ATOMIC POWER PLANTS
Ohno, T. (Ministry of Intl. Trade and Industry, Tokyo, Japan)
Karyoku Hatsuden 22(4), 349-358 (Apr. 1972)

Key Words: nuclear power plants, seismic design

Problems associated with the aseismatic design of nuclear power plants are discussed. The assumption of design earthquakes and selection of earthquake waves in various situations are analyzed. The necessity of dynamically analyzing vibrational behavior of system components in addition to static analysis is discussed. The development of computational codes for the aseismatic design of atomic power plants is described. Selection of allowable stress for the system components and general problems arising in construction are also discussed. (In Japanese)
NSA-6314

ROAD

(Also see Nos. 942, 1002, 1007)

72-1025

RECENT STUDIES GIVE UNIFIED PICTURE OF TIRE NOISE
Flanagan, W. (Automotive Engr., Soc. Auto. Engrs., Dept. 4, Two Pennsylavania Plaza, New York, N. Y.)
Automot. Engr. 80(4), 15-19 (Apr. 1972)

Key Words: automobile tires, noise generation, tires

Data from key sources are used to establish a fairly consistent picture of truck tires as a noise source. Tire sound increases with rising speed, load, and wear. Recaps of an older design are noisier than original cross lug tires which, in turn, are noisier than rib designs.

72-1026

DYNAMICS OF MOTORCYCLE IMPACT, VOLUME I -- SUMMARY REPORT: RESULTS OF CRASH TEST PROGRAM AND COMPUTER SIMULATION
Knight, R. E.; Peterson, H. C.; and Bothwell, P. W. (Denver Res. Inst., Colo.)
DRI-2574-1 (July 1971) 55 pp

Key Words: collision research, experimental results, motorcycles, simulation

The results of a series of 27 motorcycle crash tests using 50 percent anthropometric dummy riders are presented. The dummy rider is instrumented with accelerometers and a three-axis rate gyro. Five high-speed movie cameras are used to record the crash event. A parallel effort developed a digital computer simulation of the two-dimensional postcrash motion of a motorcycle and dummy rider.
PB-204997

72-1027

MEASURES TO IMPROVE THE EFFECT OF SAFETY BELTS
Vorwerk, C (Hannover)
Automobiltechnische Zeitschrift 74(2), 50-54 (Feb. 1972) 6 refs

Key Words: automobiles, collision research, safety restraint systems

The influence of vehicle deformation on stress imposed on occupants is discussed. A deceleration test stand for ascertaining the effectiveness of prestressed and loosely fitted safety belts is described. Results with belt tensions dependent on deceleration are given. (In German)

72-1028

A STUDY OF THE MAGNITUDE OF TRANSPORTATION NOISE GENERATION AND POTENTIAL ABATEMENT, VOLUME I, SUMMARY
Serendipity, Inc., Eastern Operations Div., Arlington, Va. OST-ONA-71-1-Vol.-1, (Nov. 1970) 144 pp

Key Words: aircraft noise, noise measurement, noise reduction, traffic noise

This report summarizes the results of a study to develop a long-range program for the assessment of transportation noise abatement problems and their potential solutions. The other volumes of this report address the following individual topics: measurement criteria, airport/aircraft system noise, motor vehicle/highway system noise, train system noise, community transportation noise, and abatement responsibility.
PB-206067

ROTORS

(Also see No. 1022)

SHIP

(Also see No. 921)

72-1029

COLLISION-RESISTANT STRUCTURES OF THE NUCLEAR SHIP MUTSU
Nara, S. (Ishikawajima-Harima Heavy Industries Co., Ltd., Tokyo, Japan)
Nippon Zosen Gakkaishi, No. 500, 57-61 (Feb. 1971)

Key Words: collision research, nuclear reactors, ships

Safety against collision is fully taken into consideration in the nuclear ship Mutsu, and collision-resistant structures are provided on both sides of the reactor room and auxiliary machinery room to protect machinery in reactor systems containing radioactive substances from collision with other ships. The collision-resistant structures can withstand collision with most ships. There are three methods to absorb collision energy effectively, and in Mutsu, side structures of the ship hull are stiffened, and capability to absorb destruction energy is improved. Estimation of the safety against collision is carried out on the basis of design data for the nuclear ship Savannah. Minorsky analysis is utilized for design of the first nuclear ship. Types of steel plates to be used are decided. According to the safety estimation, high-speed cargo liners are very dangerous, but sufficient safety was proved, by calculation and experiment, for the collision-resistant structures. (In Japanese)
NSA-6358

SPACECRAFT

72-1030

DYNAMIC ANALYSIS OF THE NAVAL POSTGRADUATE SCHOOL OCEAN INSTRUMENT PLATFORM
Crane, M. F.
Naval Postgraduate Sch., Monterey, Calif., Ms Thesis (Sept. 1971) 80 pp

Key Words: dynamic response, shipboard equipment response

The dynamic and static response of the proposed NPS ocean instrument platform is investigated by developing and solving linear differential equations of motion of the tower in surge, heave, and pitch. The motion is expressed as a response spectrum which is directly proportional to a wave spectrum as the exciting force. The analysis is made for various configurations of the lateral restraining cables using both a five and nine point mooring system.
AD-736117

72-1031

LATERAL DYNAMICS OF FLIGHT ON A GREAT CIRCLE
Drummond, A.M. (Auburn Univ., Auburn, Ala.)
AIAA J. 10(3), 247-251 (Mar. 1972) 9 refs

Key Words: hypersonic flight, lateral response, space shuttles

The lateral stability of a hypersonic vehicle representative of a space shuttle or hypersonic transport is calculated at two lift coefficients at speeds up to parabolic. Linearized equations of motion are used and Newtonian impact theory is utilized for stability derivative estimation. The damping in the natural modes is very small or negative, the dominant motion being an extension of the conventional Dutch Roll mode. The mode is unstable for high subcircular speeds. Coupling of the roll-convergence and spiral modes occurs at about 40 percent of circular

speed and after decoupling, some instability exists at supercircular speeds. A new undamped mode describing lateral position variation is found exactly. The results are not very sensitive to C_L and approximations to the modes are discussed and compared with the numerical solutions.

STRUCTURAL

(Also see Nos. 910, 937, 938, 949, 1008, 1020, 1029)

72-1032

SOIL-FOUNDATION-STRUCTURE INTERACTION DURING EARTHQUAKE EXCITATIONS
Brandow, G.E.
Stanford Univ., Palo Alto, Calif. PhD Thesis (1971) 233 pp

Key Words: building foundations, buildings, interaction: structure-medium, mathematical models, seismic response

The response of a building during earthquake ground motions is affected not only by the stiffness and mass characteristics of the structure, but also by the type of foundation and the properties of the underlying soil. The response of a building to an earthquake acceleration of bedrock is calculated. The effects of the soil and the structural foundation are included. A three-dimensional analytical model for soil-foundation-structure interaction is developed using a combination of one-dimensional members, two- and three-dimensional rigid bodies and three-dimensional finite elements. The analysis is limited to linearly elastic materials and small displacements. The structure is modeled with the tier building analytical model (rigid floor diaphragms, space frame members and bracing); the foundation is approximated by a rigid block in combination with piles (prismatic members with pinned ends), and the soil is idealized by a finite element mesh (three-dimensional rectangular prisms) with special boundary conditions (viscous damping at lateral boundaries and a rigid boundary at bedrock.
UM 72-5891

TRANSMISSIONS

72-1033

VALVE OSCILLATIONS IN HYDROSTATIC TRANSMISSIONS
Gel'man, A.S. and Furman, F.A.
Russ. Eng. J. 50(6), 38-42 (1971)
(Engl. transl. Vestnik Mashinostroeniya 50(6), p 39 (1971) by Production Engr. Res. Assoc.) 2 refs

Key Words: hydraulic transmission, mechanical elements, vibration control

The authors analyze the causes for the high level of vibrations which are introduced into a hydraulic transmission with long connecting mains; they suggest a frequency characteristic for a low-pressure hydraulic transmission line. They reveal the parametric character of the oscillations of feed valves and issue recommendations on how to remove valves away from parametric resonance conditions.

TURBOMACHINERY

(Also see No. 944)

72-1034

VALUATION AND SURVEILLANCE OF THE VIBRATIONAL STATE OF LARGE WATER POWER MACHINES, PARTS I AND II
Schwirzer, T. (*Siemens*, A.G., Berlin, Germany)
VDI-Z 114(1), 28-32 (Jan. 1972); 114(2), 137-140 (Feb. 1972); 14 refs

Key Words: balancing, engines, water power engines

Several criteria are nowadays available for the valuation of bearing and shaft vibrations in addition to the balancing state of rotors. Comprehensive investigations on existing plants of different design and at various rotational speeds, however, show that these criteria are not universally applicable to water power engines. This holds in the first place for machines with vertical axis of rotation running at low speeds and for machines with special bearing designs. However, the existing experiences allow for deriving new valuation criteria which are valid for all types of water power engines. This succeeds only if the existing oscillatory forces and not the exciting vibrations are submitted to a valuation;

thereby, the specific unbalance which is equivalent to the exciting forces can be taken as a measure for these. A valuation diagram based on this characteristic parameter is proposed for discussion. Furthermore, some special requirements are dealt with which vibration surveillance facilities for water power machines must satisfy. (In German)

USEFUL APPLICATION

72-1035

MICRORELIEVING RUBBING SURFACES BY DIAMOND VIBROBURNISHING
Bunga, G.A.
Russ. Engr. J. 50(6), 56-57 (1971)
(Engl. transl. Vestnik Mashinostroeniya 50(6) p 55 (1971) by Production Engr. Res. Assoc.) 1 ref

Key Words: metal working, vibratory techniques

Metal seizure is one of the most dangerous forms of wear, and the operational safety and life of components of rubbing pairs largely depends on the stated conditions and lubrication of their working surfaces, and particularly on the microrelief. Diamond vibroburnishing, one of the most effective ways of optimizing the microrelief of surfaces, is examined.

AUTHOR INDEX

BOOKS

DYNAMIC STABILITY OF STRUCTURES
George Herrmann, ed.
International Conference on Dynamic Stability of Structures,
Evanston, Illinois, 1965
Pergamon Press, New York, N. Y. (1967)

These are Proceedings of an International Conference held at the Technological Institute of the Northwestern University in October 1965. The book contains excellent articles by eminent scientists, engineers and mathematicians, which survey and represent mathematical methods of analysis of physical phenomena and design applications in engineering or report on current research (1965) on the theme of the conference, "Dynamical Stability of Structures", presented in a keynote address by Professor N. J. Hoff. The emphasis is on the applied side and only those parts of the theory are surveyed which are of current interest in applications. The book is highly recommended to the scientific community and particularly those who are interested in the development of the stability theory or its applications. To bring out the scope of the book the titles of various articles with authors are reproduced herewith:

Stability of Continuous Systems
J. J. Stoker

Stability Theory and the Asymptotic Behavior of Dynamical Systems
J. P. LaSalle

Statistical Aspects in the Theory of Structural Stability
V. V. Bolotin

Dynamic Buckling of Elastic Structures: Criteria and Estimates
B. Budiansky

Survey of Problems of Structural Dynamic Stability in Vehicle Design
J. M. Hedgepeth

Stability Problems in the Control of Saturn Launch Vehicles
G. F. McDonough

Buckling of Long Slender Ships Due to Wave-Induced Whipping
S. R. Heller, Jr. and J. T. Kammerer

Elimination of the POGO Instability from the Gemini Launch Vehicle
R. L. Goldman

Stability and Vibration Problems of Mechanical Systems under Harmonic Excitation
E. Mettler

Dynamic Plastic Buckling
J. N. Goodier

Dynamic Buckling under Step Loading
J. M. T. Thompson

Some Studies on the Nonlinear Dynamic Response of Shell-Type Structures
D. A. Evensen and R. E. Fulton

Dynamic Stability of a Column under Random Loading
S. T. Ariaratnam

Interaction of Mechanical and Aeroelastic Instabilities of a Circular Cylindrical Shell
Y. C. Fung

Dynamic Buckling of a Circular Ring Constrained in a Rigid Circular Surface
T. H. H. Pian, H. A. Balmer and L. L. Bucciarelli, Jr.

Energy Considerations in the Analysis of Stability of Nonconservative Structural Systems
G. Herrmann and S. Nemat-Nasser

Recent Italian Contributions in the Field of Dynamic Stability of Structures
L. Finzi and E. Giangreco

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SHOCK WAVES AND MECHANICAL PROPERTIES OF SOLIDS

J. Burke and V. Weiss
Syracuse University Press,
Syracuse, N.Y. (1971)

The book was found to be of high level and quality and this is due in a great part to the efforts of the distinguished authors included in the book. The problems discussed are very timely, significant, and presented in such a manner as to enhance the value of each section. The inclusion of wave effects in monolithic materials, composite materials, rocks, and porous materials under one cover is excellent and unique.

It is not possible to review each section in detail but the sections on composite materials is very good and points out the difficulties in analysis of the attenuation/dispersion of such materials. The compressive fracture at interfaces of composite materials is a difficult and interesting problem and it is refreshing to find that others are aware of the importance of the problem.

The book could serve as a text on wave effects in materials for advanced graduates and will be very useful for researchers in this area in that it presents many timely and related subjects in one book.

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AEROSTRUCTURES

Selected Papers of Nicholas J. Hoff
R. B. Testa, ed.
Pergamon Press, Elmsford, N.Y. (1971)

This book is a collection of 19 of Professor Hoff's most significant papers, chosen by the editor, R. B. Testa, from his list of 164 publications. The papers range in time from 1941 to 1968. Their subject matter includes stress analysis, dynamic buckling, creep, stability, and thermal stresses. Although they are primarily theoretical, the theory is usually presented in relation to practical aeronautical structures. Typical titles are "Stresses in a Reinforced Monocoque Cylinder under Concentrated Symmetric Transverse Loads", "The Applicability of Saint-Venant's Principle to Airplane Structures", and "Thermal Buckling of Supersonic Wing Panels." Four journals, two proceedings, and one special volume are represented, but most of the papers are reprinted from the Journal of Applied Mechanics, the Journal of the Aeronautical Sciences, or the Journal of the Royal Aeronautical Society. Included are the 1954 Wilbur Wright Memorial Lecture, "Buckling and Stability", and the 1967 Von Karman Lecture, "Thin Shells in Aerospace Structures."

The book begins with a preface by Bruno Boley, one of Hoff's first students, in which Hoff's career is reviewed and some of his most significant work is briefly commented upon. Next comes a list of the 36 doctoral students who have written their theses under his direction. The front matter concludes with a complete bibliography of Professor Hoff's 164 papers.

The papers themselves are evidently reproduced by photo-offset from reprints of the original journals. This leads to a variety of type faces and sizes, but the whole is very readable.

Anyone interested in aircraft structures, in creep, or in structural instability should obviously have this collection on his shelves for historical reasons and for ready reference to some of its more recent contents. Graduate students and beginning workers in these fields should read it both for the material and to gain inspiration from this cross section of a quarter-century in the life of a great theoretical engineer.

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ELECTROACOUSTICS

M. L. Gayford
STC Monograph
American Elsevier Publishing Co., Inc.
New York, N.Y. (1971)

This is a well written book for the advanced "Stereophile" as well as the engineer needing information relative to the design and use of acoustic devices. A basic understanding is conveyed without reference to the time-worn analogies or heavy mathematics of years past. The book is divided into six parts designed to

treat the several aspects of electroacoustics. No recognition is given to the existence of underwater sound.

Part 1 provides an introduction to transducer design principles and techniques. While an engineer will not learn all the cookbook recipes of the various transducer arts, he has adequate information for complete design of prototype equipment capable of performing specified tasks. This treatment extends to a good understanding of magnetic circuits for electrodynamic transducers as well as many of the niceties of piezoelectric systems.

Part 2 deals with communication microphones and earphones used in specific applications such as high-noise or low-cost telephone equipment. The carbon microphone is treated at some length as are the moving iron transducers so universally used in the telephone industry. Gradient microphones of first and second order are discussed and the discrimination characteristics of these transducers are shown.

Part 3 discusses high quality microphones used in the laboratory and the broadcast industry. Microphones for these uses tend to be ribbon and capacitor types, both of which have well damped resonant responses out of the frequency range of use. These two types are well covered with some discussion of the moving coil as a quality device. Some mention is made of highly directional microphones.

Part 4 speaks for itself. Loudspeakers are discussed. It begins with brief descriptions of the various cabinet types and the usual nebulous discussion of room mode coupling. Since this is a field where little is understood and much is expounded, it is surprising that the author is so definite in his statements. However, he is brief and then launches into an excellent treatment of the moving coil transducer as the almost universal loudspeaker. Other types are mentioned in passing and more is said about cabinets. The entire part is conspicuous by the lack of arithmetic.

Part 5 concerns itself with acoustics measurements on loud speakers and transducers. Objective and subjective measurements of both microphone and speaker responses are shown to be useful under stated conditions and these measurements are described.

Part 6 consists of appendixes dealing with various developments in the telephone industry and the usual conversion tables. A good index is included with this book.

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PAPERS AND REPORTS

THE ANALYSIS OF CURVED MULTISPAN STRUCTURES

Henderson, J. P. and McDaniel, T. J.
J. Sound and Vib. 18(2), 203-219
(Sept. 1971)

Refer to Abstract No. 71-1542

Experience has shown that there is little correlation between the response across frames of fuselage structures when subjected to aeroacoustic loads, but strong correlation across a finite number of stringers. This led researchers to investigate the vibration of flat panels stiffened in one direction by stringers. The most popular method to emerge from the considerable activity in this area is the transfer matrix method. The present paper extends this method to the analysis of singly curved panels stiffened by stringers, thus representing the actual structure more realistically.

The paper begins by giving details of the derivation of the field transfer matrix of a shell segment and the point transfer matrix of a thin open-section stringer. This is followed by a discussion of the use of these transfer matrixes in determining the response of the complete structure to harmonic and random loads. Finally, a procedure for determining the response of closed periodically stiffened shells is given. At all stages the numerical difficulties likely to be encountered are described and methods of overcoming them presented. Comments are also made regarding the practical application of the method to a given structure. The only omission in this area are the details (specific or referenced) of the procedure to be adopted if either the matrix $\underset{\sim}{A}$ (Eq. 4) or matrix $\underset{\sim}{T}$ (Eq. 24) has any repeated eigenvalues.

The details of a number of numerical analyses are presented. The free and forced vibrations of both a 5 and a 56 span closed periodic structure are presented. The latter structure was represented by both shell and beam models. The results show that the modal patterns of the 5 span structure differ from the corresponding flat structure due to the curvature effects. Also the modal density of the response of a complete structure is much higher than that found in a finite length laboratory test specimen.

The paper represents a significant advance in the prediction and understanding of the response of fuselage structures to excitation in the audio-frequency range. As such it will be of interest to both analysts and designers.

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EXPERIMENTAL STUDIES OF UNDERWATER NOISE IN THE OCEAN

Bardyshev, V.I.; Velikanov, A.M.; and Gershman, S.G.

Soviet Physics-Acoustics, Transl. Akusticheskii Zhurnal 16(4), 512-513 (Apr./June 1971)

Refer to Abstract No. 71-1037

With a continuing interest in underwater noise phenomena shown by the major countries of the world in their roles of developing, among other things, ocean resources, it is interesting to contemplate some of the work being done in the Soviet Union. This paper concerns the spectral content of ambient sea noise. Ambient sea noise has been of major concern to the scientific community since Langevin (Ref. 1) first applied piezoelectric materials to the problem of sound detection of underwater vehicles.

In the present paper, the authors refer to the work of Wenz (Ref. 2) who hypothesized that low frequency ambient sea noise, whose spectral density increases by 8 to 12 dB per octave with a lowering of frequency, is the result of turbulent pulsations of the liquid flow acting on the surface of the measurement hydrophone. The reported research tries to verify this, in part, with the presentation of data gathered for water flow rates across the hydrophone of up to 14 m/sec in water depths of 100 to 130 m. Data was gathered from two spherical transducers: The first one was located 60 m below the free surface, unshielded from the flowing sea currents; the second hydrophone was positioned 1.5 m above the sea bed and shielded with a dense fabric stretched over a spherical, rigid frame, much in the same way as a windscreen which is used to attenuate wind effects on a microphone. Resulting data indicated that underwater ambient noise intensity at low frequencies is lowered by the presence of the flow shield.

Because the Rayleigh Numbers for the flows around the hydrophones were large, even for values of velocity as small as 0.2 m/sec, flow was turbulent as required by Wenz's theory. However, other factors must be considered. First, the noise cannot be attributed wholely to wind effects as these have been shown to be of relatively minor importance with respect to noise in shallow water (Ref. 3). In a sound channel, ambient noise is found to be the result of local winds and long-range sources (Ref. 4). Of more immediate interest is a study conducted by Arase (Ref. 5) who showed that the ambient noise measured in shallow water depths (80 f) on the sea bed is a function of wind noise whereas bottom noise in deep water (900 f) depends more on long-range sources with a maximum intensity centered about 50 Hz. Perrone's study (Ref. 6) reveals that ambient sea noise is, directly related to depth, decreasing in intensity with increasing depth and frequency. Noting the researchers positioning of their hydrophones with the unshielded unit located at a higher depth than the shielded unit, it becomes questionable as to Wenz's theory. The experimental arrangement does not differentiate between the effects of so-called current induced noise and noise associated with water depth. In fact, with the stated positions of the hydrophones it is to be expected that the results would tend toward agreement with Wenz. Therefore, the results of this paper cannot be considered of definite value. Further work remains to be done.

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ASSESSMENT OF ANNOYANCE DUE TO VARYING NOISE LEVELS WITH PARTICULAR REFERENCE TO AIRCRAFT NOISE
Muller, J.L.
J. Sound and Vib. 19 (3), 287-298 (Dec. 8, 1971)

Refer to Abstract No. 72-467

If the amount of effort spent searching for a solution to a technological problem is a measure of the complexity and importance of the problem, then the assessment of annoyance resulting from noise must be both complex and important. Indeed, annoyance due to noise was considered important at least 40 years ago, but the development of a unified system of assessment has not yet been achieved. If such a system were to be developed its importance would be considerable.

Beranek, Kosten and Van Os and the Wilson Committee on Noise, among others, have tried to quantify annoyance. More recently, Robinson has produced evidence that the variability of the noise, as well as the overall level, influence the assessment of annoyance. In the paper under review Muller takes Robinson's thesis but uses an electrical analogy, in which induced emf is assumed to be analogous to the subjective responses to the temporal aspects of transient stimuli, to evaluate the correction due to the variability of the noise. Using this concept, he goes on to develop a logarithmic function which is similar in form to those used in other fields of sensory psychology, such as brightness and roughness.

He applies these corrected equivalent noise levels to noises of predetermined annoyance level (for example, the Heathrow survey) and the results appear to be encouraging. The method has certain advantages. Like Robinson's Noise Pollution Level (NPL), it can be applied equally to road traffic noise or aircraft noise and it assesses the total noise environment. Furthermore, it overcomes a disadvantage of the NPL concept in that it is equally applicable either to single noise events or to recurrent events. It can also be applied with a reasonable degree of success to short duration noises such as sonic booms. Of major importance, the calculations involved are simple.

Although at present there is a flood of new units for the assessment of annoyance some have more value than others. The NPL was one such unit, and I suggest that the proposals of Muller might be considered as an extension, rather than an alternative, to the concept. Whether the extension will be found to be worthwhile, only time will tell. The author himself says that he would be the first to admit that more work needs to be done to establish reliable values for certain of the empirical parameters in the proposed correction method. It is, however, an interesting proposal and it deserves serious consideration. No doubt Muller himself will communicate further evidence as it becomes available, and other researchers will probably assess the value of the method. Until that time it is difficult to give a definite opinion of its value, but it certainly seems to have merit and deserves further attention.

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RESONANCE CLASSIFICATION IN A CUBIC SYSTEM
Ness, D.J.
J. Appl. Mech., Trans. ASME 38 (3), 585-590 (Sept. 1971)

Refer to Abstract No. 71-1499

A weakly nonlinear system of one degree-of-freedom subjected simultaneously to a time-varying external force and parametric excitation has been treated. Two basic cases have been distinguished according to the magnitude of the external force. It was in one case considered small and in the other case not. By applying the asymptotic method of averaging (here in the form of Van der Pol) the critical frequency relationships leading to resonant oscillations have been obtained up to the first order. Certain critical values of the excitation frequencies produce resonant oscillations. They have been

classified and stability has been presented for the case of harmonic and parametric resonance. For the case of small exterior force the resonant behavior of the vibrator could be categorized as follows:

1. If the linearized natural undamped frequency is unequal to the forcing frequency and the parametric frequency is unequal to twice the forcing frequency, the system is said to be nonresonant.

2. If the linearized natural undamped frequency is equal to the forcing frequency but the parametric frequency is not equal to twice the forcing frequency, then the system possesses harmonic response.

3. If the linearized natural undamped frequency is unequal to the forcing frequency, but the parametric frequency is twice the forcing frequency, then the vibrator possesses parametric resonance.

4. If the forcing frequency is equal to the linearized natural undamped frequency and the parametric frequency, then the system has both one-half of harmonic and parametric resonance.

For the case that the excitation force is not small, the following results have been given:

1. The system is nonresonant, if the linearized undamped natural frequency is not equal to one-third or three times the forcing frequency and if the parametric frequency is not equal to twice the forcing frequency.

2. Subharmonic resonance occurs for the linearized undamped natural frequency being one-third of the forcing frequency and the parametric frequency not being equal to two- or four-thirds of the forcing frequency.

3. Superharmonic resonance is obtained if the linearized undamped natural frequency is three times the forcing frequency and the parametric frequency is not equal to two, four or six times the forcing frequency.

4. If the undamped linearized natural frequency of the system is not one-third or three times the forcing frequency, but the parametric frequency is twice that of the forcing frequency, then the vibrator is in parametric resonance.

5. There is a combination resonance, if the undamped linearized natural frequency is not one-third or three times the forcing frequency, but the parametric frequency is either one unit larger or smaller than the forcing frequency.

6. Subharmonic, parametric and combination resonance occurs for a parametric frequency of two-thirds and an undamped linearized natural frequency or one-third of that of the forcing frequency.

7. In the case of these values being four-thirds and one-third respectively of the forcing frequency a subharmonic and parametric resonance occurs.

8. In the case of six and three respectively a superharmonic and parametric resonance occurs.

9. If the natural linearized undamped frequency is three times that of the forcing frequency, and the parametric frequency is two or four times that of the forcing frequency, then there occurs superharmonic and combination resonance.

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STATISTICAL APPROACH TO COMPLEX RANDOM VIBRATION
Zeman, J. L. and Bogdanoff, J. L.
J. Acoust. Soc. Am. 50 (3), 1019-1027 (Sept. 1971)

Refer to Abstract No. 71-1546

When measurement uncertainties, manufacturing tolerances, or other factors preclude deterministic definition of a structure, it may be statistically defined in terms of an ensemble of realizations (nominally alike structures differing in detail). The authors are concerned with obtaining the ensemble average of an arbitrary response quantity when the excitation (to each structure in the ensemble) is a random process. Specifically, they present and demonstrate an analytical method for estimating the response of statistically defined structures to stationary random vibration in hopes of clarifying the statistical energy analysis (SEA) approach to such problems. The method consists of the following steps:

1. Idealize the structure, supports and couplings. Regard the physical parameters in the idealization as random variables.

2. Compute the response quantity for a single realization of the structure.

3. Calculate the desired statistic of the response quantity using an appropriate probability distribution for the random parameters.

The authors apply the method in a straightforward way to two closely related problems. In both cases a simply supported Bernoulli-Euler beam is excited transversely at a point by a wideband stationary random force. Damping is assumed to be light and damping ratios identical for all resonant modes; nonresonant modes are neglected. In the first problem mean square velocity at a point is calculated by the method. It compares favorably with the authors' averages of deterministic response calculations for random locations of excitation and response points. In the second problem, an additional beam is coupled by a light spring to the excited beam. Mean energy of the directly excited beam and mean power flow through the coupling are calculated.

The authors share with other SEA workers an interest in obtaining response quantities other than energy and power, and also in accounting for uneven distribution of natural frequencies over the band of excitation (Ref. 1). Methods similar to the one presented in this paper have been used profitably in other applications such as nonstationary vibration (Ref. 2) and free vibration (Ref. 3), as well as stationary random vibration (Ref. 1). Such methods, undoubtedly will find continued use both in SEA and elsewhere.

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MODE INTERACTION SEGREGATION FOR NONLINEAR DIFFERENTIAL EQUATIONS
Giorgini, A. and Toebes, G.
Intl. J. Nonlinear Mech. 6(4), 549-561 (Aug. 1971)

Refer to Abstract No. 71-1550

Equations representing engineering vibration problems are often linearized under the constraint of "small" deflections. When such a formulation predicts an instability (the coefficient of velocity is negative), it is recognized that the resulting "large" deflections can modify this damping coefficient and produce a limit cycle oscillation. A nonlinear equation having this characteristic is the Van der Pol equation:

$$\ddot{x} - \alpha\ (1 - x^2)\ \dot{x} + x = 0$$

where α is a positive constant. The damping coefficient is $-\alpha\ (1 - x^2)$ which is negative for small x but becomes positive for $|x| > 1$. The periodic solution to this equation represents a self-excited limit cycle oscillation and for this reason is of much interest in the field of nonlinear vibrations.

Various approaches have been used to obtain solutions to this equation including: graphical methods, numerical integration, and perturbation methods. The approach of this paper is different from those previously used and represents an interesting innovation.

The steady state solution may be represented by an infinite Fourier expansion. For $\alpha \neq 0$ the coefficients all interact with each other. In perturbation methods, the zeroth approximation

is a linear solution and successive approximations each yield one additional Fourier coefficient. Because of the laborious algebra there is a practical limit on the number of Fourier amplitudes which may be obtained.

The method given in this paper expresses the Fourier amplitudes as a power series in α. By considering the order of the infinitesimals in α (for small α) in the expressions, the authors are able to truncate the series to include only terms which will be significant and to limit the region over which the summations in the solution take place (i.e., the modal interactions). This process leads to a simplification of the problem without losing its nonlinear characteristics even for the zeroth approximation and results in a scheme of successive improvements.

The method, as distinguished from perturbation methods, produces approximate values of all the Fourier coefficients at each step. The authors have found from numerical experiments that the method has yielded good results for α up to at least one and appears to have application for all values of α.

It is recommended that all those interested in nonlinear vibration problems investigate the method presented in this paper.

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COMPUTATION OF THE RESPONSE OF COUPLED PLATE-ACOUSTIC SYSTEMS USING PLATE FINITE ELEMENTS AND ACOUSTIC VOLUME-DISPLACEMENT THEORY
Craggs, A.
J. Sound and Vib. 18 (2), 235-245
(Sept. 22, 1971)

Refer to Abstract No. 71-1558

The response of elastic plate-acoustic systems to sudden loads has an obvious motivation, the need to determine the behavior of window panels subjected to sonic boom. In early studies the effect of acoustic support was either ignored or inadequately modeled. The subject paper considers the support due to shallow acoustic enclosure using a simple two-mode approximation of the plate behavior. The results of this analysis, while in qualitative agreement with experimental data show a sizeable effect of acoustical support and thus the advisability of a more detailed study.

The author studies the problem by: (1) using a finite element model of the elastic plate, and (2) including the effect of the acoustic medium by considering only the change in plate support pressure caused by change in volume of the acoustic medium. This volume change is assumed to be due to the plate displacement only.

These assumptions lead to a standard set of equations of motion with the system stiffness matrix taken as a sum of plate and acoustic effects. The problem is thus cast as a type of elastically supported plate, i.e., a problem where momentum transfer between plate and acoustic medium is neglected. For this study a standard 16 degree-of-freedom plate element is used and the entire plate is modeled by 16 elements. The results show, for both clamped and simply supported rectangular plates, that the lowest volume displacement modes are most sensitive to acoustic effects. Here the frequency and mode shapes depend strongly on the ratio of acoustical stiffness to plate stiffness. When this ratio is small, corresponding to a small window in a large room, the effect of acoustical support is small; when the ratio is large, corresponding to a large window in a small room, the effect is substantial.

The Runge-Kutta procedure is used to solve for the plate response due to an N wave excitation. The results for the acoustic pressure are in qualitative agreement with experimental data and the plate response agrees favorably with the earlier approximate studies.

Since the experimental data used to check the analysis only indicates qualitative agreement (as for the two-mode analyses) it is difficult to ascertain the extent of improvement of the refined model over the earlier investigations. However, the detailed study of model dependence on acoustical stiffness indicates system response which is of interest, especially

when considering plate stresses. Computation of the dependence of transient stresses on acoustic stiffness would have added to the scope of the paper.

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SIGNATURE ANALYSIS OF TURBOMACHINERY
Bannister, R. L. and Donato, V.
J. Sound and Vib. 5(9), 14-21
(Sept. 1971)

Refer to Abstract No. 72-46

The article reviews the general topics of protection evaluation and analysis procedures for current and future needs, in relation to large steam turbines. Future prospects, in terms of increased size complexity and criticality, suggest the need for more advanced methods for measuring and analysis. A brief discussion of instrumentation includes the common analyzers and the time-compression types, together with notes about correlation and averaging techniques. Experimental examples include the problem of detecting blade condition through bearing or journal measurements. The bibliography includes 42 items, which, together with the article are likely to be of much interest to those concerned with the safety and economics of turbine operation.

This article is concerned with vibration, although it tends to suggest an acoustic approach. The term "signature analysis" might well be replaced by the term "vibration spectrum", which appears clearer, as well as being more pertinent to fixed-speed machines such as turbines. One example is given of corresponding spectra at low pressure blade and at journal of shaft. This is obtained by shaking the blade of the stationary turbine, while measuring at both blade and shaft. The interesting result emerges that the vibration at the blade is attenuated by about 50 dB, or say 300:1, during its travel to the point of measurement at the journal. This attenuation refers to the fundamental mode of the blade; and it appears that attenuations as great as 3000:1 may arise in relation to the third or fourth harmonics. The significance of the extreme attenuation is that it may make difficult the separation of the blade contribution from the total signal that is measured at the journal.

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FORCED VIBRATION OF INTERNALLY DAMPED CIRCULAR AND ANNULAR PLATES WITH CLAMPED BOUNDARIES
Snowdon, J. C.
J. Acoust. Soc. Am. 50(3), 846-858
(Sept. 1971)

Refer to Abstract No. 71-1547

The classical thin plate equations can be extended to account for the internal damping of the plate material by expressing the elastic moduli as complex quantities. Thus one can, for example, express the complex Young's modulus at any temperature by

$$E_w^* = E_w (1 + i \delta_{Ew})$$

where δ_{Ew} is the damping factor associated with the dynamic Young's modulus E_w at any angular frequency w and $i = (-1)^{1/2}$. It has been noted experimentally that the damping factor in shear δ_{Gw} can be set equal to the damping factor in tension for plastic and rubber-like materials. For metals there exists a slight difference in their values. Also, for many materials the dynamic modulus and the damping factor vary slowly with frequency and may be considered as constant throughout the range of frequencies normally occurring in vibration problems. This assumption provides a good approximation to the behavior of most common metals, thermoplastics such as Lucite and crystalline polymers such as Teflon.

These assumptions are incorporated by the author to determine the vibration response of sinusoidally driven circular and annular plates with clamped boundaries. The response of such internally damped plates can be expressed in terms of ordinary and modified Bessel functions of complex argument. In particular, the paper presents expressions for the driving point impedance, transfer impedance and force transmissibility for the following problems:

(1) the vibration of circular plates driven by a point force at their midpoints, where they either mass loaded or elastically restrained;

(2) the vibration of annular plates driven by a ring force of arbitrary radius;

(3) the vibration of annular plates driven by either one or two ring forces;

(4) the vibration of a centrally driven circular plate that is loaded, at any arbitrary radius, by an ideally concentric annular mass.

For each of these problems representative computations are carried out for several values of the damping ratio and are plotted in terms of a parameter proportional to the square root of the frequency. All of the results obtained are discussed and interpreted in a very lucid manner. Some of the principal conclusions to be drawn from the results are:

(1) additional mass placed directly beneath the driving force is a very effective means of increasing plate impedance and of blocking force transmission to the boundary;

(2) a heavily damped constraining spring is effective in increasing driving point impedance and reducing force transmission at resonance when the relative stiffness is small and at nearly all frequencies when the relative stiffness is large;

(3) the impedance and transmissibility for an annular plate with large outer to inner radius ratios are very much like those for the solid plate while for small ratios the plate becomes more and more stiff;

(4) dual ring force excitation provides a very significant reduction in transmissibility at all frequencies greater than the fundamental frequency;

(5) a ring distribution of mass is not nearly as effective in reducing force transmission as when lumped directly underneath the driving force.

The paper is highly recommended to all persons with an interest in the effect of damping on the response of mechanical and structural systems. It is however, recommended that an earlier companion paper by the same author be read first, namely, "Forced Vibration of Internally Damped Circular Plates with Supported and Free Boundaries" (J. Acoust. Soc. Am. 47(3), 882-891, 1970).

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ASYMPTOTIC THEORY OF RESONANCE IN CONSERVATIVE NONLINEAR SYSTEMS
Kovtoune, R.I.
Intl. J. Nonlinear Mech. 6(4), 479-493 (Aug. 1971)

Refer to Abstract No. 71-1552

The problem considered in this paper is that of a vibrating system excited by an external periodic force when the excitation frequency and the natural frequency are both analytic functions of the output amplitude. The constant amplitude of the excitation is assumed to be small enough to justify using the asymptotic method developed by Bogoliubov and Mitropolski.

The author first justified the use of the appropriate asymptotic equations, even though they have a pole at a=o (a is the amplitude of the solution). His conclusions are correct here, but his arguments appear unclear and his choice of "initial conditions" is off by π radians due to a sign error in the linear approximation that is given.

The main contribution of the paper is the derivation of the time dependence of the phase and amplitude of the first approximation of the output for several specific cases of resonance. The amplitude and phase are given in terms of Jacobi functions, but very little analysis of the solution is given, so it is hard to see exactly how the solution behaves in the resonance case. The work appears to be more useful for continued engineering research than for the solution of practical engineering problems.

The final point made in the paper is that the solutions for the resonance regime reduce to linear theory solutions when the difference in natural and excitation frequencies becomes large.

This difference is allowed to get large in such a way that amplitude dependence is negligible and hence the linear comparison is appropriate. Unfortunately, the linear resonance solution is used for comparison rather than the linear nonresonance solution, which is the appropriate one to use when the frequency difference becomes large. If, however, the appropriate comparison is made, then the author's work does not reduce to the linear nonresonance case. Perhaps higher order asymptotic terms would make the comparison more accurate.

The value of this paper is questionable because of several mistakes and the very unclear arguments and statements. Perhaps the main results are valid, but in order to have confidence in them, one would have to redo most of the analysis.

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NONLINEAR STRUCTURAL ANALYSIS BY DYNAMIC RELAXATION
Brew, J.S. and Brotton, D.M.
Intl. J. Numer. Methods Engr. 3(4), 463-483 (Oct./Dec. 1971)

Refer to Abstract No. 72-102

Dynamic relaxation is a relatively new iterative procedure for solving simultaneous equations that has two iteration parameters in contrast to over-relaxation which has one. The authors apply this method to nonlinear frame analyses but perhaps the most important contribution of the present paper is their analysis that determines optimum values for the two iteration parameters in linear problems. To solve the matrix equation $Kd = W$, dynamic relaxation integrates the differential equations

$$G\ddot{d} + C\dot{d} + Kd = W \qquad (1)$$

Where fictitious mass and damping matrixes have been introduced and the transient solution converges to the desired static solution. The authors use first-order backward differences in Eq. (1) to obtain

$$\dot{d}_{M+1} = \dot{d}_M + a\, G^{-1}\left[W - Kd_M - C\dot{d}_M\right] \qquad (2)$$

$$d_{M+1} = d_M + a\, \dot{d}_{M+1} \qquad (3)$$

where a is the time interval. Taking the matrix $G^{-1}C = rI$ leads to the following relations for the optimal iteration parameters

$$ar = \frac{2}{\rho^2}\left[(1-\rho^2)^{1/2} - (1-\rho^2)\right] \qquad (4)$$

$$a^2 = \frac{4}{\rho(\mu_1 - \mu_m)}\left[1 - (1-\rho^2)^{1/2}\right] \qquad (5)$$

where μ_1 and μ_m are the largest and smallest eigenvalues of $G^{-1}K$ respectively and $\rho = (\mu_1 - \mu_m)/(\mu_1 + \mu_m)$. The problem of selecting iteration parameters for linear equations is thus reduced to estimating the largest and smallest eigenvalues of $G^{-1}K$. Equation (5) reduces to the equation for the optimum over-relaxation factor when K is p-cyclic with p=2. The convergence rate of dynamic relaxation compares favorably with over-relaxation but the authors failed to compare it with other pertinent iterative algorithms such as the conjugate gradient method.

Computational results presented in the paper for frame structures indicate that the performance of dynamic relaxation is inferior to direct solution for linear problems and inferior to an iterative direct solution procedure for nonlinear problems. These findings are in general agreement with those of most investigators, including the reviewer, who have compared iterative methods with sparse matrix decomposition methods for solving simultaneous equations. The authors do, however, argue that dynamic relaxation offers certain storage advantages and is more easily programed. The widespread availability of good out-of-core sparse matrix decomposition routines for matrixes of dimension 10,000 and larger is evidence that in practice any storage advantage dynamic relaxation may have is of minor importance.

A rather thorough analysis of the dynamic relaxation method is contained in this paper with emphasis on optimum iteration parameters. The authors also present candid results which demonstrate that there are better methods available for solving both linear and nonlinear simultaneous equations.

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THE EFFECTS OF NONUNIFORM SWASHPLATE STIFFNESS ON COUPLED BLADE-CONTROL SYSTEM DYNAMICS AND STABILITY -- PART I: ANALYSIS AND APPLICATION
Piarulli, V.J.
NASA CR-1817, 81 pp (Sept. 1971)

Refer to Abstract No. 72-277

This report presents the results of a study directed at investigating the effects of an anisotropically mounted flexible swashplate, including blade out-of-track, on the vibratory and mechanical stability characteristics of helicopter rotor systems. The analysis which has been developed is based on a combined Laplace transform and associated matrix approach. The program yields complex eigenvalues which indicate frequency and rate of growth or decay of a natural mode of the complex system. Blade modal response and swashplate motion corresponding to a given eigenvalue are predicted.

Interblade coupling and the presence of any nonuniformity in the torsional stiffness constraint as the azimuth position changes have significant effects on the torsional vibration characteristics of a rotating helicopter blade, especially the lower modes. To a less extent the periodically varying control stiffness may affect both the flapwise bending and edgewise bending if there is strong coupling between these degrees of freedom, and either the feathering or torsional degrees of freedom. In addition, studies done on a three-bladed rigid rotor system with a gyro stabilizer showed a strong influence of the gyro on interblade coupling. With respect to out-of-blade track, studies of the stability of both the three- and four-bladed rotor systems showed that this effect was less significant than support asymmetry.

In the present analysis there are no provisions for applied aerodynamic loads or for perturbation aerodynamics as a result of blade motions. Thus, all analytical results obtained are effectively those for a rotor in a vacuum. However, the analysis and programs have been developed so as to be directly useful in more extensive aeroelastic computer programs which are yet to be developed. The computer program listing for the present analysis is presented in Part II.

The report presents a very detailed analysis of studying the dynamic ..bility of helicopter rotor systems. Matrix approach is fine if one is interested in the actual responses. However, it seems that a direct solution to the governing differential equations may arrive at some more meaningful stability charts. For instance, by considering a rigid blade in torsion, and a swashplate stiffness resembling the second harmonic function, one may find himself solving a Mathieu equation, and the stability chart for a Mathieu equation is well-defined.

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FORCED VIBRATION OF A BEAM WITH TIME-DEPENDENT BOUNDARY CONDITIONS
Africk, D.J. and Loo, T-C.
ASME Hq. (1971)

Refer to Abstract No. 72-68

This paper presents a method to solve beam vibration problems under the following assumptions and/or conditions:

1. Bernoulli-Euler beams,
2. constant cross section,
3. no distributed loading, and
4. a time-dependent boundary condition.

According to the method, to solve a specific problem is is necessary to choose functions $g(x)$ and $\phi_n(x)$, $n=1,2,\ldots$ The ϕ_n's are defined as the normal mode functions but are treated as "arbitrary" functions, apparently as an approximation. A restriction is that these functions satisfy the boundary conditions. Sensitivity of the solution to different choices of $\phi_n(x)$ and $g(x)$ is not discussed. As a result, the accuracy of the approximations is unknown. An example of a clamped-hinged beam is provided.

It is not clearly acknowledged by the authors that Meirovitch (Ref. 1) solves the same problem without approximations and with a bit more generality (including an arbitrary distributed forcing function).

The authors use the second derivative of the dynamic displacement response to obtain the bending moment and the stress. This dynamic

stress response has the form of an infinite series summed over an index n and contains terms of the order of n^3/ω_n^2, where ω_n is the nth natural frequency. No discussion of convergence is attempted. A brief discussion of fatigue is presented based upon this stress function for the example beam.

The introduction states that Galerkin's method is used; however it was not evident where, if at all, it enters the method.

REFERENCE

1. Meirovitch, L., Analytical Methods in Vibrations, MacMillan Co., New York, N.Y. (1967).

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VIBRATION OF FLUID-FILLED FIBER-REINFORCED SPHERICAL SHELLS
Naghieh, M. and Hayek, S. I.
J. Sound and Vib. 19(2), 153-166
(Nov. 22, 1971)

Refer to Abstract No. 72-368

The authors investigate the natural frequencies and mode shapes of fiber-reinforced, composite, spherical shells filled with an incompressible liquid. The composite shell is replaced analytically by a homogeneous orthotropic shell, and the fluid pressure is derived from a velocity potential. The governing differential equations are formulated from an energy principle. The general form of the solution is an infinite series of Legdendre polynomials. It was necessary to obtain solutions for the natural frequencies numerically since the eigenvalue matrix was of infinite size.

Most of the previous research in this field has found application in the design of liquid fuel rockets, but the authors give only one reference to this large body of work. The authors do mention, however, that their work might be used in the design of high-pressure storage tanks.

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VIBRATIONS OF A COMPOSITE ANNULAR MEMBRANE
De, S.
J. Sound and Vib. 17(1), 13-23
(July 8, 1971)

Refer to Abstract No. 71-1355

This paper presents the free vibration solutions for an annular membrane composed of one or more concentric regions. The author terms this type of multiple region membrane a "composite membrane." The governing equation for displacement in a given annular region and the associated boundary conditions on displacements and slopes for all such regions are given in standard polar coordinate form. The tension force is assumed to be constant throughout the entire membrane. The mass per unit area is constant within a given concentric region.

The eigenvalue solution is obtained in the standard manner by using separation of variables and the boundary conditions at the inner, outer, and intermediate annular boundaries. In solving for the eigenfunction, through the use of the boundary conditions, the author obtains 2n equations and constants when using n concentric regions. These are presented in recurrence and matrix form from which the frequency determinant, frequency equation, and mode shape functions are given.

Orthogonality expressions are obtained for the eigenfunctions (mode shape functions) involving integrals over the regions. The free vibration solution is completed for the displacement in each region by superposition of the principal modes and combining the initial conditions for membrane displacement and velocity with the orthogonality conditions.

Two major solutions are given. The first is for a uniform annular membrane subdivided into n concentric regions. The second is for a single annular region where the mass per unit area varies as a function of the radius, i.e., a nonuniform annular membrane. In both cases solutions for symmetric and asymmetrical modes are given in separate form. Derivation of the nonuniform case is not given in detail.

Numerical examples treated include: one region membrane with a uniform mass distribution, one region membrane with the mass per unit area proportional to the radius to a constant power, two region membrane where the mass distribution is nonuniform in each concentric region, and a two region membrane where the mass distribution is constant within each region but not the same from region to region. The numerical examples give frequency equations only and in the last example cited, comparison is given to show how the first nondimensional frequency parameter varies as a function of the mass ratio for the two regions.

The author's treatment is concise and the form of the principal mode solutions given should be readily applicable with numerical means by most analysts working in the vibration area. A minimal number of references are given.

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CALENDAR

Meeting	Date 1972	Location	Contact
National Transportation Engineering Conference, ASCE	JULY 17-21	Milwaukee, Wis.	Meetings Manager, ASCE Hq.
National West Coast Meeting, SAE	AUG. 21-24	San Francisco, Calif.	A. J. Favata, SAE Hq.
6th *International Conference on Nonlinear Oscillations*, Acad. Sci. USSR, Czech. Acad. Sci., German Acad. Sci., Polish Acad. Sci.	29-4	Poznań, Poland	Polish Acad. Sci., Inst. Fundamental Tech. Res., Organizing Committee of the 6th Intl. Conf. Nonlinear Oscillations, Warsaw, Swietokrzyska 21, Room 334, Poland
Applied Mechanics Western Conference, ASME	29-31	Honolulu, Hawaii	A. B. Conlin Jr., ASME Hq.
National Combined Farm Construction and Industrial Machinery and Powerplant Meeting, SAE	SEPT. 11-14	Milwaukee, Wis.	A. J. Favata, SAE Hq.
National Aeronautic and Space Engineering and Manufacturing Meeting, SAE	OCT. 2-6	San Diego, Calif.	A. J. Favata, SAE Hq.
International Conference on Noise Control Engineering, INCE	4-6	Washington, D.C.	M. J. Crocker, R. W. Herrick Labs., School Mech. Engr., Purdue Univ., Lafayette, Ind. 47907
12 US Mechanisms Conference, ASME	8-11	San Francisco, Calif.	A. B. Conlin Jr., ASME Hq.
Industrial and General Applications Group Annual Meeting, IEEE	9-12	Philadelphia, Pa.	J. A. Herrmann, ITE Circuit Breaker Co., 1900 Hamilton St., Philadelphia, Pa. 19130
Symposium for Gearing and Transmissions, IFToMM, ASME, AGMA	11-12	San Francisco, Calif.	A.I. Tucker, Mail Zone C-3, Solar Div., Intl. Harvester Co., 2200 Pacific Hwy., San Diego, Calif. 92112
Annual and National Environmental Meeting, ASCE	16-20	Houston, Tex.	Meetings Manager, ASCE Hq.
Fall Meeting, SESA	17-20	Seattle, Wash.	B. E. Rossi, SESA Hq.
16 *Stapp Car Crash Conference*, Wayne State Univ., Univ. Mich., SAE, Univ. Calif.	NOV. 8-10	Detroit, Mich.	A. J. Favata, SAE Hq.
Winter Annual Meeting, ASME	12-16	New York, N.Y.	A. B. Conlin Jr., ASME Hq.
Fall Joint Computer Conference, AFIPS	14-16	Las Vegas, Nev.	D. R. Crusen, AFIPS Hq.
Fall Meeting, ASA	27-1	Miami Beach, Fla.	M. Kronegold, Inst. Marine Sci., Richenbacker Causeway, Miami, Fla. 33149
75th Anniversary Meeting, ASTM	DEC. 3-5	New Orleans, La.	H. H. Hamilton, ASTM Hq.
43rd Shock and Vibration Symposium	5-7	Asilomar, Calif.	Shock and Vibration Information Center, Washington, D.C. 20390
Automotive Engineering Congress and Exposition, SAE	1973 JAN. 8-12	Detroit, Mich.	A. J. Favata, SAE Hq.
Dynamics Specialist Conference, AIAA	MAR. 19-20	Williamsburg, Va.	Meetings Manager, AIAA Hq.
14th Structures, Structural Dynamics and Materials Conference, AIAA, ASME, SAE	20-23	Williamsburg, Va.	Meetings Manager, AIAA Hq.
International Convention and Exhibit, IEEE	26-29	New York, N.Y.	J. M. Kinn, IEEE Hq.

CALENDAR

Meeting	Date 1973	Location	Contact
Annual Structural Engineering Meeting, ASCE	APR. 9-13	San Francisco, Calif.	Meetings Manager, ASCE Hq.
Joint Railroad Technical Conference, IEEE, ASME	11-12	St. Louis, Mo.	IEEE Hq.
International Congress on Experimental Mechanics, SESA	MAY 13-18	Los Angeles, Calif.	B. E. Rossi, SESA Hq.
National Automobile Meeting, SAE	14-18	Detroit, Mich.	A. J. Pavata, SAE Hq.
Spring Joint Computer Conference, AFIPS	15-17	Atlantic City, N.J.	H. G. Asmus, AFIPS Hq.
14*th* Joint Automatic Control Conference, AIAA, AIChE, ASME, IEEE	JUNE 20-22	Ohio State Univ. Columbus, Ohio	H. R. Weed, Dept. EE, Ohio State Univ., Columbus, Ohio 43210
76th Annual Meeting and Exposition, ASTM	24-28	Philadelphia, Pa.	R. H. Hamilton, ASTM Hq.

ACRONYM DEFINITIONS AND ADDRESSES OF SOCIETY HEADQUARTERS

AFIPS: American Federation of Information Processing Societies
210 Summit Ave., Montvale, N.J. 07645

AGMA: American Gear Manufacturers Association
1330 Mass. Ave., N.W., Washington, D.C.

AIAA: American Institute of Aeronautics and Astronautics
1290 Sixth Ave., New York, N.Y. 10019

AIChE: American Institute of Chemical Engineers
345 E. 47 St., New York, N.Y. 10017

ARPA: Advanced Research Projects Agency

ASA: Acoustical Society of America
335 E. 45 St., New York, N.Y. 10017

ASCE: American Society of Civil Engineers
345 E. 47 St., New York, N.Y. 10017

ASME: American Society of Mechanical Engineers
345 E. 47 St., New York, N.Y. 10017

ASNT: American Society for Nondestructive Testing
914 Chicago Ave., Evanston, Ill. 60202

ASQC: American Society for Quality Control
161 W. Wisconsin Ave., Milwaukee, Wis. 53203

ASTM: American Society for Testing and Materials
1916 Race St., Philadelphia, Pa. 19103

IEEE: Institute of Electrical and Electronics Engineers
345 E. 47 St., New York, N.Y. 10017

IES: Institute Environmental Sciences
940 E. Northwest Highway, Mt. Prospect, Ill. 60056

IFToMM: International Federation for Theory of Machines and Mechanisms
US Council for *TMM*, c/o Univ. Mass., Dept. ME,
Amherst, Mass. 01002

INCE: Institute of Noise Control Engineering

ISA: Instrument Society of America
400 Stanwix St., Pittsburgh, Pa. 15222

ONR: Office of Naval Research
Code 400B4, Dept. Navy, Arlington, Va. 22217

SAE: Society of Automotive Engineers
2 Pennsylvania Plaza, New York, N.Y. 10001

SEE: *Society of Environmental Engineers*
68a Wigmore St., London W1H 9DL, England

SESA: *Society for Experimental Stress Analysis*
21 Bridge Sq., Westport Conn. 06880

SNAME: *Society of Naval Architects and Marine Engineers*
74 Trinity Pl., New York, N.Y. 10006

URSI-USNC: *International Union of Radio Science - US National Committee*
c/o MIT Lincoln Lab., Lexington, Mass. 02173